

REMARKS

Applicants' attorney wishes to request a personal interview with the Examiner to further discuss this amendment and the prior art. Applicants' attorney will contact the Examiner in the near future.¹

In the Office Action, various claims were rejected under 35 U.S.C. §112 as being indefinite and for lacking antecedent basis. In response, claims 41, 115, 117 and 119 have been amended to provide proper antecedent basis.

In addition, attached as Appendix A is a publication entitled "Relative Ignition Propensity of Test Market Cigarettes" that was published by the National Institute of Standards and Technology. The attached article discusses the "Cigarette Extinction" test method and its use dating back to 1993. In particular, the Examiner's attention is directed to Appendix D, beginning on page 25 of the article, which describes the test method in detail. As stated in Applicants' specification, the Cigarette Extinction test was developed by the National Institute of Standards and Technology and is well known to those skilled in the art. As stated in Applicants' previous response, the Cigarette Extinction Test is now also referred to in the industry as ASTM Test Designation No. E2187-04. Applicants submit that one skilled in the art was well aware of this test as published by the National Institute of Standards and Technology making claims 41, 115, 117 and 119 sufficiently definite for purposes of 35 U.S.C. §112.

Currently, claims 41-65, 68-108 and 110-120 are pending including independent claims 41, 70, 83 and 113. The claims are generally directed to a paper wrapper and to a smoking article incorporating the wrapper. In accordance with the present disclosure, all of the claims require that the paper wrapper have a relatively high permeability. In particular, the permeability of the wrapper is **greater than about 60 Coresta**.

The paper wrapper also includes treated discrete areas which reduce the ignition proclivity characteristics of a smoking article made with the wrapper. For example, claim 41 requires that the treated discrete areas have a permeability less than about 25 Coresta and a BMI ("Burn Mode Index") of less than about 5 cm⁻¹.

In the recent Office Action, the claims continued to stand rejected under 35 U.S.C.

¹ Applicants' attorney was unsuccessful in requesting an interview with the Examiner prior to filing this response.

§ 103 over U.S. Patent No. 5,878,753 to Peterson in view of U.S. Patent No. 4,739,755 to Hampl and further in view of U.S. Patent No. 6,298,868 to Hampl.

In Applicants' previous response, Applicants argued that Peterson actually teaches away from the use of a paper wrapper having a permeability of greater than about 60 Coresta. In response, the latest Office Action asserted that Peterson "teaches that any commercially available cigarette paper may be employed" and that Peterson "places neither explicit nor implicit limitations upon the porosity of the paper that may be employed in the invention." In this regard, the Office Action asserts that Peterson only teaches providing a gradually decreasing permeability profile in the treated areas and "provides neither an express nor implicit limitation upon the porosity of the base paper."

Applicants are appreciative to the Examiner for a detailed explanation of the Examiner's position in relation to the response that was previously filed. Applicants submit, however, that when Peterson is viewed in its entirety, one skilled in the art having common sense at the time of the invention would not have reasonably considered incorporating a paper web having a permeability of greater than about 60 Coresta in the smoking articles disclosed therein. In fact, a close examination of Peterson reveals that Peterson does explicitly teach away from using a base paper having a relatively high permeability.

Peterson is directed to producing paper wrappers for smoking articles with reduced ignition proclivity characteristics "without adversely affecting smoking characteristics." In column 2, for example, Peterson states that a "significant drawback" in conventional banded papers is that "a noticeable change in the smoking characteristics of the cigarette can be detected as the cigarette coal burns into the treated bands." Starting at line 32 of column 2, Peterson then states:

A noticeable difference in taste and smoke delivery is discernible by the smoker depending on the difference in permeabilities between the untreated and treated sections of the paper. (emphasis added)

Thus, Peterson is directed to "minimizing the chance of discernible changes in smoke delivery and taste to a smoker."

One technique that Peterson uses to accomplish the above objective is to design treated areas that have a gradually decreasing or increasing permeability profile. Peterson,

however, also makes clear that the permeability difference between the treated areas and the untreated areas should be minimized.

With respect to the treated areas, Peterson teaches that the treated areas have a permeability of less than 6 Coresta. In fact, Peterson discusses the treated areas having a permeability of less than 6 Coresta at four different locations in the patent:

- 1) A desired permeability range for the maximum sustained permeability reduction of the treated areas is less than 6 ml/min/cm², and generally within a range of essentially 2 to 6 ml/min/cm². (column 3, lines 36-39).
- 2) Applicants have determined that a preferred permeability is less than 6 ml/min/cm² (CORESTA), and generally within a range of 2 to 6 ml/min/cm². (column 5, lines 57-60).
- 3) Treated areas 18 have a permeability within a range known to cause self-extinguishing of the cigarettes, for example, within a range of 2 to 6 ml/min/cm². (column 7, lines 20-23).
- 4) The area of maximum permeability reduction is within a range of 2 to 6 ml/min/cm² (column 10, lines 47-48).

With respect to the untreated areas, Peterson only discloses a single type of base paper, namely Kimberly-Clark KC Grade 603 paper which has an average porosity of 32.6 Coresta.

Finally, in column 9, Peterson unequivocally states that the treated areas or bands:

may also have an undesirable discontinuous effect on the delivery of smoke and taste to the smoker. These undesirable effects may exist regardless of the type of solution used to form the bands. **For example, if the change in permeability between the treated areas and untreated areas of the cigarette is relatively great, the smoker will discern a difference in taste and smoke delivery.** (emphasis added).

Thus, as shown above, Peterson does in fact explicitly teach minimizing the permeability difference between the treated areas and the untreated areas. Using a base paper having a permeability of greater than 60 Coresta would dramatically increase the difference in permeability between the treated areas and untreated areas and would be in direct conflict with the teachings of the reference.

Specifically, as pointed out above, Peterson teaches and emphasizes over and over again that the treated areas should have a permeability of from 2 to 6 Coresta. The only base paper Peterson actually discloses has a permeability of 32.6 Coresta. The difference in permeability between the base paper and the treated areas is thus about 27 Coresta units.

Replacing the 32.6 Coresta base paper with a base paper having a Coresta of greater than 60 Coresta units as required in the claims would then necessarily create a difference in permeability between the treated areas and the untreated areas by at least 50 Coresta units which is almost a two-fold increase in the difference in permeability between the treated areas and the untreated areas. Such a modification to Peterson flies in the face of its own teachings when viewing the reference in its entirety.

As correctly noted by the Examiner, Peterson does state that “any manner of commercially available cigarette wrapper” can be included in the article. Applicants submit, however, that the above statement does not focus in any way on the permeability of the paper. Paper wrappers for smoking articles, for example, have a variety of properties. These include basis weight, tensile strength, opacity, inclusion of burn chemicals and fillers, and permeability. Interpreting the general remark in column 7 of Peterson as opening the door to the use of high permeability papers is inconsistent with the teachings of Peterson and amounts to no more than hindsight reconstruction of Applicants’ invention.

In the Office Action, the Examiner also requested that Applicants provide some evidence of non-obviousness regarding the combination of Peterson with Hampl. In this regard, the Examiner’s attention is directed to the materials attached to this response in Appendix A, Appendix B and Appendix C. The attached documents are submitted to show that one skilled in the art at the time of the filing of the patent application would not have reasonably looked at a cigarette wrapper with relatively high permeability for constructing a cigarette having reduced ignition proclivity characteristics. In the past, cigarette papers having a high permeability were found to significantly increase the risk of starting fires when left burning on an adjacent surface.

For example, in the past, various studies were completed showing that cigarettes containing relatively high permeability wrappers created a much greater fire hazard and

had a much greater propensity to ignite adjacent substrates. In this regard, the Examiner's attention is directed to the document included as Appendix B which are relevant pages from a technical study entitled "The Effect of Cigarette Characteristics on the Ignition of Soft Furnishings" dated October 1987 and published by the Center for Fire Research National Bureau of Standards in accordance with the Cigarette Safety Act of 1984. The technical study group was directed to undertake studies to make cigarettes safer, and especially to identify different physical characteristics of cigarettes which have an impact on ignition of upholstered furniture and mattresses. The work of the technical study group was commissioned by the U.S. Government.

As stated on page 3, three cigarette characteristics were found to have a significant impact on ignition proclivity. Those three characteristics included low tobacco density, reduced circumference, and a low paper permeability. See particularly Table ES-2 entitled "Ignition Propensity as a Function of Experimental Cigarette Characteristics" on page 2. As shown in the table, one of the cigarette parameters that was tested is paper permeability. As indicated in the table, a high permeability paper significantly increased the propensity of the cigarette to start a fire in comparison to a similar cigarette containing a low permeability paper.

Attached as Appendix C is a publication entitled "Overview: Practicability of Developing a Performance Standard to Reduce Cigarette Ignition Propensity" published by the U.S. Consumer Product Safety Commission in August of 1993. On page 3, this document references the technical study included in Appendix B discussed above and states that paper porosity is one of the characteristics of cigarettes that affects the risk of ignition. On page 12, the report states that wrapper paper porosity was found to have a **"significant effect"** on the risk of fire and that cigarettes with higher paper porosity exhibited a **"higher fire risk"**. On page 13, the report further states that the observed "high risk" for high paper porosity has been confirmed in laboratory studies.

Similarly, the publication included with Appendix A entitled "Relative Ignition Propensity of Test Market Cigarettes" states on page 1 that:

Research showed that there were three modifications of the cigarette that would reduce its likelihood of starting a fire: reduced tobacco packing density, smaller cigarette circumference, and less porous paper.

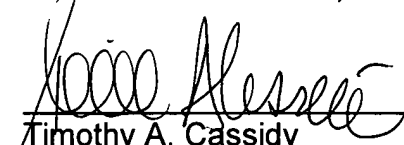
Thus, the evidence included in the appendices shows that at the time of Applicants' invention, those skilled in the art were taught, based on actual laboratory analysis, that paper wrappers having a relatively high permeability are unsuitable for use in reduced ignition propensity applications. In particular, papers having relatively high permeability are known to burn faster and hotter and therefore actually increase the propensity of cigarettes to ignite adjacent objects.

In view of the above evidence, Applicants submit that it would not have been obvious to somehow combine the Hampl references with Peterson. Specifically, based upon the teachings of Peterson and upon the overwhelming evidence of record, one skilled in the art having common sense at the time of the invention would not have used a relatively high permeability paper, namely a paper having a permeability of greater than 60 Coresta, in the applications described in Peterson.

In summary, Applicants submit that the present application is in complete condition for allowance. Should any issues remain after consideration of this response, however, then Examiner Lazorcik is invited and encouraged to telephone the undersigned at his convenience in the hopes of expeditiously resolving any such issues.

Respectfully submitted,

DORITY & MANNING, P.A.


Timothy A. Cassidy
Reg. No. 38,024
P.O. Box 1449
Greenville, SC 29602
(864) 271-1592
(864) 233-7342

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APPENDIX A

“Relative Ignition Propensity of Test Market Cigarettes”

NIST Technical Note 1436

Relative Ignition Propensity of Test Market Cigarettes

Richard G. Gann, Kenneth D. Steckler, Schuyler Ruitberg, William F. Guthrie and Mark S. Levenson

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



NIST Technical Note 1436

Relative Ignition Propensity of Test Market Cigarettes

Richard G. Gann, Kenneth D. Steckler, and Schuyler Ruitberg
Building and Fire Research Laboratory

William F. Guthrie and Mark S. Levenson
Information Technology Laboratory

National Institute of Standards and Technology
Gaithersburg, MD 20899-8650

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U.S. Department of Commerce
Norman Y. Mineta, Secretary

Technology Administration
Dr. Cheryl L. Shavers, Under Secretary of Commerce for Technology

National Institute of Standards and Technology
Karen H. Brown, Acting Director

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ABSTRACT

The Federal Trade Commission (FTC) staff requested that the National Institute of Standards and Technology (NIST) conduct tests to determine whether a test market cigarette made with a slower burning paper would reduce the risk that such a cigarette, if dropped or discarded, would start a fire. While NIST does not routinely perform product tests, it agreed to do so in this case, recognizing the important role of the FTC in assuring the public of the veracity of product claims and the high potential for less fire-prone cigarettes to reduce fire deaths and injuries. NIST staff purchased conventional and modified cigarettes from the test market and measured the relative ignition propensities of the two cigarette types using the Mock-up Ignition Test Method and the Cigarette Extinction Test Method, both developed under the Fire Safe Cigarette Act of 1990. Analysis of the test data shows that the modified cigarette has a lower relative ignition propensity than the conventional cigarette.

Keywords: fire, cigarette, ignition

THE RESEARCH ON REDUCED IGNITION PROPENSITY CIGARETTES CONDUCTED BY NIST SINCE 1984 WAS DONE IN THE INTEREST OF SAVING LIVES AND PROPERTY FROM CIGARETTE-INDUCED FIRES. IN NO WAY DOES IT LESSEN OR NEGATE THE HEALTH HAZARDS AND ADDICTIVE NATURE OF SMOKING AS DETERMINED BY THE SURGEON GENERAL OR SUGGEST THAT NIST AND THE DEPARTMENT OF COMMERCE CONDONE SMOKING.

Certain commercial materials and products are identified in this report to specify the procedures adequately. Such identification is not intended to imply recommendation or endorsement by NIST.

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I. INTRODUCTION

Cigarettes dropped onto upholstered furniture and beds continue to be the leading single cause of fire deaths in the United States. The Consumer Product Safety Commission (CPSC) estimated that in 1997, cigarette-ignited fires resulted in about 880 deaths, 2120 injuries, and a direct property loss of \$335 million.¹ A 1993 report had estimated the total cost to our society of \$5 billion.²

Over the past three decades, most of the fire safety standards effort has been directed at improving the resistance of the fuel (mattresses³, commercial furniture⁴, and residential upholstered furniture⁵) to the ignition source. These standards have contributed to reducing these losses significantly.⁶ However, the median life of these furnishings has been estimated at 12 years for mattresses and 15 years for upholstered furniture⁷, so most of the old items have been replaced, and little additional decrease in fire losses is expected from these standards.

There have also been efforts to reduce the potency of the ignition source, the cigarette, by reducing its propensity to ignite soft furnishings. Research under two Federal Acts, each of three-year duration, has generated substantial technology in this direction:

The Cigarette Safety Act of 1984 (P.L. 98-567). Research showed that there were three modifications of the cigarette that would reduce its likelihood of starting a fire: reduced tobacco packing density, smaller cigarette circumference, and less porous paper.⁸ A shorter tobacco column length, the absence of a filter tip, and the absence of a burn additive in the paper had effects in limited cases.

In addition, five patented modifications were tested. All five showed significantly reduced ignition propensity relative to identical cigarettes without the patented feature.⁸

¹ Mah, J., Smith, L., and Ault, K., "1997 Residential fire Loss Estimates," U.S. Consumer Product Safety Commission, 2000.

² Ray, D.R., Zamula, W.W., Miller, T.R., Cohen, M.A., Douglass, J.B., Galbraith, M.S., Lestine, D.C., Nelkin, V.S., Pindus, N.M., Smith-Regojo, P., "Societal Costs of Cigarette Fires," Report No. 6, Technical Advisory Group, Fire Safe Cigarette Act of 1990, U.S. Consumer Product Safety Commission, August 1993.

³ 16 CFR 1632.

⁴ Based on "E 1352 Standard Test Method for Cigarette Ignition Resistance of Mock-up Upholstered Furniture Assemblies," Annual Book of ASTM Standards, Vol. 4.07, ASTM, Philadelphia, PA.

⁵ Based on "E 1353 Standard Test Method for Cigarette Ignition Resistance of Components of Upholstered Furniture," Annual Book of ASTM Standards, Vol. 4.07, ASTM, Philadelphia, PA.

⁶ Comparison of data in the CPSC National Fire Loss Estimates for 1984 and 1997 shows a 40% reduction in deaths and injuries.

⁷ Private communication, M. Neily, U.S. Consumer Product Safety Commission, 2000.

⁸ Gann, R.G., Harris, Jr., R.H., Krasny, J.F., Levine, R.S., Mitler, H.E., and Ohlemiller, T.J., *The Effect of Cigarette Characteristics on the Ignition of Soft Furnishings*, Report No. 3, Technical Study Group on Cigarette and Little Cigar Fire Safety, Cigarette Safety Act of 1984, and NBS Technical Note 1241, U.S. National Bureau of Standards, Gaithersburg, MD, 1987.

The Fire Safe Cigarette Act of 1990 (P.L. 101-352). Among other products, this Act resulted in:

- Two methods for measuring the ignition propensity of a cigarette type.⁹
 - The Mock-up Ignition Method measures whether a cigarette causes ignition by transferring enough heat to a fabric/foam simulation of a piece of furniture (substrate). A lit cigarette is placed on one of three different mock-ups. Ignition (failure) is defined as the char propagating 10 mm away from the tobacco column. The procedure is repeated a set number of times and the percent of failures is calculated.
 - The Cigarette Extinction Method measures whether a cigarette, when placed on a heat-absorbing substrate, burns long and strong enough to cause ignition had it been dropped on a piece of furniture. A lit cigarette is placed on one of three substrates consisting of a fixed number of pieces of common filter paper. Failure is defined as the cigarette burning its full length. The procedure is repeated a set number of times and the percent failures is calculated. [While the metric in this test is the cessation of burning, it is not a test for “self-extinguishing” cigarettes. Some cigarette designs that pass this procedure have also performed well in the Mock-up Test, burning their full length without causing an ignition.]

The two methods produce similar results. Both were subjected to an interlaboratory evaluation (ILE) to measure their reproducibility. In addition, NIST tested 20 commercial cigarettes and 5 experimental cigarettes using the two methods.

- A cigarette smoke toxicity testing plan.¹⁰ A panel of experts from government, industry and academia developed a four-tier plan, proceeding from rapid and inexpensive tests to longer, more costly measurements.
- Estimation of the societal costs of cigarette fires.²

Efforts to develop a Federal standard for less fire-prone cigarettes have been unsuccessful. In June of this year, the State of New York became the first jurisdiction to enact such legislation. Other states are considering similar action.

On January 11, 2000, a major manufacturer of cigarettes announced that it would soon be test marketing a modification of one of their cigarettes that would make them less likely to start a fire. Having evolved from one of the patented ideas tested under the Cigarette Safety Act of 1984, the modification entails adding circumferential bands of low air permeability paper to the paper that wraps the tobacco column. These bands were said to reduce the rate of burning, making it more difficult for the cigarette to heat furnishings and cause ignition.

⁹ Ohlemiller, T.J., Villa, K.M., Braun, E., Eberhardt, K.R., Harris, Jr., R.H., Lawson, J.R., and Gann, R.G., *Test Methods for Quantifying the Propensity of Cigarettes to Ignite Soft Furnishings*, NIST Special Publication 851, National Institute of Standards and Technology, 1993.

¹⁰ Lee, B.C., Mishra, L.C., Burns, D.M., Gairola, C.G., Harris, J.E., Hoffman, D., Pillsbury, Jr., H.C., and Shopland, D.R., “Toxicity Testing Plan,” Report No. 5, Technical Advisory Group, Fire Safe Cigarette Act of 1990, U.S. Consumer Product Safety Commission, August 1993.

On May 15, 2000, soon after the test marketing of the modified cigarettes began, Joan Z. Bernstein, Director of the Federal Trade Commission (FTC) Bureau of Consumer Protection, sent a letter to Dr. Jack E. Snell, Director of the National Institute of Standards and Technology (NIST) Building and Fire Research Laboratory (BFRL), requesting that NIST "conduct tests to determine whether and to what extent this cigarette does reduce the risk of ignition." On May 19, 2000, Dr. Snell replied "While NIST does not routinely perform product tests, we recognize the important role of the Federal Trade Commission in assuring the public of the veracity of product claims and the high potential for less fire-prone cigarettes to reduce fire deaths and injuries. We thus agree to measure the ignition propensity of these test cigarettes relative to the performance of the unmodified product. Note that this is not an absolute measure of ignition probability in real circumstances, but is a strong indicator as to whether a reduction in cigarette-initiated fires might be expected." Copies of the two letters appear as Appendices A and B to this report.

This report presents the results of the NIST testing of the ignition performance of the conventional cigarettes and the modified (banded) product. While the only publicly stated difference between the two types was the banding of the wrapping paper, NIST performed no tests to ascertain that there were not additional differences.

II. WORK PLAN

Three sets of measurements were carried out. These are described in reverse order of their execution to clarify the rationale for each component of the project.

- A. *Tests to determine the extent of difference in ignition propensity between the conventional and modified cigarettes.* Both the Mock-up Ignition Method and the Cigarette Extinction Method were used. The apparatus and procedures, given in Appendices C and D, respectively, are the same as those used in the 1993 study.⁹ In each case, a sufficient number of repetitions were performed to ensure that we could see real changes, yet few enough to produce results in a timely manner.
- B. *Tests to help estimate the impact of the modified cigarettes.* Doing this required placing the results in the context of the extensive testing on experimental and commercial cigarettes performed under the two Acts.
 - 1. This task was to "calibrate" the mock-up substrates relative to those used in the 1993 testing. This involved using two experimental cigarettes of different ignition strengths (types 529 and 531 from the 1990 Act⁹) and determining the extent to which the new substrates performed as their 1993 counterparts did.
 - 2. This "calibration" required knowing that the extent to which the two experimental cigarette types showed the same ignition strength as in 1993. (They had been stored in freezers since then.) For this, the two were checked against each of two filter paper substrates for which data had been taken in 1993. This filter paper is invariant over the years.

III. MATERIALS AND METHODOLOGY

A. Cigarettes

1. **Experimental Cigarettes.** A supply of the experimental cigarettes provided by the cigarette industry during the course of the Fire Safe Cigarette Act of 1990 had been stored in freezers at approximately 0 °C since that time. Two were selected for this project:⁹
 - Cigarette 529 was 100 mm in length and 25 mm in circumference, manufactured of expanded, flue-cured tobacco, and wrapped in paper of low air permeability.
 - Cigarette 531 was also 100 mm in length and 25 mm in circumference and manufactured of expanded, flue-cured tobacco. The tobacco was wrapped with paper of conventional air permeability.
2. **Commercial Cigarettes.** Cartons of the test cigarettes with the banded paper were purchased in Denver, CO (one of the test market cities) in May 2000. Cartons of conventional cigarettes of the same brand were purchased at a different location on the same date in the same city. The cigarettes¹¹ were characterized as follows:

Weight: Both the conventional and modified cigarettes weighed 1.030 g each.

Band structure: The band dimensions were determined to provide an approximate characterization for identification of these cigarettes. The bands were approximately 6 mm in width and were spaced by about 20 mm. Details are provided in Appendix E. Neither the porosity nor the air permeability of the paper or the bands was measured.

No further chemical or physical measurements were performed on either set of cigarettes. Thus, it is not known whether there were any additional differences between the conventional and modified packings.

B. Substrate Materials

1. **Fabrics.** The #4, #6, and #10 cotton ducks used in this study were taken from stock remaining from the 1993 ILE conducted by NIST.⁹ Since 1993, the ducks have been stored at NIST in a conditioning room, nominally at a relative humidity of 50 ± 5 % and a temperature of 21 °C ± 3 °C.

Cigarette industry studies^{12,13} had shown that some fabrics produced reversals in the ordering of cigarette ignition performance. These reversals were said to be more likely with fabric areal densities in the range 0.30 kg/m² to 0.44 kg/m² (9 oz/yd² to 13 oz/yd²).

¹¹ Both types of cigarettes were Merit Ultra Light 100s. Certain commercial materials and products are identified in this report to specify the procedures adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology.

¹² Spears, A.W., Rhyne, A.L., and Norman, V., "Factors for Consideration in a Test for Cigarette Ignition Propensity on Soft Furnishings," *J. Fire Sciences* 13, 59-83 (1995).

¹³ Lewis, L.S., Morton, M.J., Norman, V., Ihrig, A.M., and Rhyne, A.L., "The Effects of Upholstery Fabric Properties on Fabric Ignitabilities by Smoldering Cigarettes. II," *J. Fire Sciences* 13, 445-471 (1995).

We designed the current study to include one or more such fabrics to determine whether the relative performance of the conventional and banded cigarettes might reverse. Canvassing the local fabric/upholstery stores, we purchased 19 100 % cotton fabrics in this weight range. Each showed smoldering afterglow when ignited with a small flame from a propane torch and then blown out. However, only one of these then supported smoldering ignition from a cigarette. This material had an ivory color and an areal density of 0.36 kg/m^2 (10.5 oz/yd^2). We purchased a continuous length from a single bolt of this fabric for use in this study.

2. **Foam.** Non-fire-retarded flexible polyurethane foam has become a specialty item not routinely stocked by vendors. Owing to a lack of inventory, the manufacturer of the non-fire-retarded polyurethane flexible foam used in the 1993 standard mock-up tests (no. 2048 from Vitafoam Inc., High Point, NC) could not supply material for the present study within the available time frame. We learned that Philip Morris U.S.A. had on hand a supply of the 200 mm x 200 mm x 50 mm foam blocks. NIST purchased from Philip Morris 1000 pieces of that non-fire-retarded foam for the present study. An essential component of the test plan (Section III.E) is a determination of whether the substrates using this new foam perform the same as the 1993 substrates. A successful comparison would both enable comparison of the new data with the 1993 results and quell any concerns about the source of the new foam blocks. The test results reported in Section IV.B. of this report show there was no difference in ignitability between the substrates made with the new foam and the corresponding substrates in the 1993 study.
3. **Film.** The polyethylene film used with the #4 cotton duck substrates in this study was taken from stock left over from the 1993 ILE.⁹ Since 1993, the roll of film has been stored at NIST in its original cardboard shipping box.
4. **Filter Paper.** The paper used was 150 mm diameter Whatman #2 filter paper that was taken from stock remaining from the 1993 ILE.⁹ Since 1993, the paper has been stored at NIST in the original sealed boxes containing 100 papers each.

C. General Test Procedure

Four test chambers were employed in executing each method. A *test point* is defined as an evaluation of a specific cigarette/substrate/procedure combination. Each test point was evaluated simultaneously in the four test chambers. These four simultaneous test point determinations are called a *test set*. A *test cycle* is the combination of all possible test points (performed in consecutive test sets) in a randomized sequence.

C. Verification of the Ignition Propensities of Experimental Cigarettes

A series of tests was performed to determine whether the ignition propensities of cigarettes 529 and 531 had remained unchanged since 1993. For the sake of time, each cigarette was tested on only two of the original filter paper substrates: 3 and 10 layers for cigarette 529, 10 and 15 layers for cigarette 531. Cigarettes from four packs were randomized and an identification number was printed in pencil on the filter tip of each cigarette. Six test sets were performed for each test point, resulting in 24 repetitions per test point. The results were to be compared with the NIST results from the 1993 interlaboratory evaluation (ILE) of the two test methods.

The randomized sequence of tests was:

Cycle	Test Point			
1	1	2	4	3
2	1	3	2	4
3	3	1	4	2
4	4	1	3	2
5	3	1	2	4
6	1	2	3	4

where the test points were:

Test Point	Cigarette	Test Type	# Layers
1	529	Extinction	3
2	529	Extinction	10
3	531	Extinction	10
4	531	Extinction	15

E. Evaluation of the Susceptibility of the Foam/Fabric Film Substrates

A second series of tests was performed to determine the degree of similarity of the new substrates (consisting of long-stored fabrics and film and a different batch of foam) to those in the 1993 ILE. Two substrates were tested using the two experimental cigarettes: the #10 and #6 cotton duck substrates were tested with cigarette 529, the #6 and #4 cotton duck substrates were tested with cigarette 531. In addition to the randomization of the cigarettes, the pieces of foam, fabric and film were also randomized and labeled. Six test sets were performed for each test point, resulting in 24 repetitions per test point. The results were again to be compared with the NIST results from the 1993 ILE. The randomized sequence of tests was:

Cycle	Test Point			
1	2	4	1	3
2	1	2	4	3
3	2	1	4	3
4	4	2	1	3
5	4	3	2	1
6	2	3	4	1

where the test points were:

Test Point	Cigarette	Test Type	Duck #
1	529	Mockup	6
2	529	Mockup	10
3	531	Mockup	4
4	531	Mockup	6

F. Evaluation of the Relative Ignition Propensities of the Banded Cigarettes

A third series of tests was performed to determine the relative ignition propensities of the conventional and banded cigarettes. Both were tested using the two test methods. For the Mock-up Ignition Test, additional testing was performed with a substrate consisting of the ivory cotton fabric and the standard polyurethane foam. All component materials were randomized and labeled. Eight test sets were performed for the fabric substrates, six test sets for the filter paper substrates. The randomized sequence of Cigarette Extinction Test Method testing was:

Cycle	Test Point					
1	6	4	5	2	1	3
2	1	3	5	4	6	2
3	2	1	5	4	3	6
4	5	6	1	2	3	4
5	5	2	3	6	4	1
6	5	4	6	2	1	3

where the test points were:

Test Point	Cigarette	# Layers
1	Conventional	3
2	Conventional	10
3	Conventional	15
4	Banded	3
5	Banded	10
6	Banded	15

The randomized sequence of the Mock-up Ignition Test Method testing was:

Cycle	Test Point							
1	4	3	1	7	8	6	2	5
2	8	2	5	3	6	4	1	7
3	7	8	4	3	6	1	2	5
4	5	4	7	8	2	1	3	6
5	7	4	2	1	6	5	8	3
6	2	4	1	7	5	6	8	3
7	1	2	6	3	7	4	8	5
8	1	4	6	3	5	2	7	8

where the test points were:

Test Point	Cigarette	Fabric
1	Conventional	Duck #4
2	Conventional	Duck #6
3	Conventional	Duck #10
4	Conventional	Ivory
5	Banded	Duck #4
6	Banded	Duck #6
7	Banded	Duck #10
8	Banded	Ivory

G. Statistical Evaluation Methodology

The data obtained from these experiments were analyzed to determine whether the ignition propensities of the experimental cigarettes had changed during storage, the similarity of the new mock-ups to those used in 1993, and the degree of difference between the conventional cigarettes and those with the banded paper. The statistical analysis consisted of two steps:

1. selection of an appropriate set of statistical methods for estimating and comparing the measurements of relative ignition propensity of different types of cigarettes under different conditions as laid out in the series of experiments; and
2. analysis of the data for each set of test conditions individually, along with the comparisons of ignition propensities obtained under different test conditions.

The analysis of the data obtained under each individual test condition is relatively easy to interpret because it is given directly in terms of ignition propensity. Having this information on hand aids understanding of the somewhat less easily interpreted comparisons of different test conditions, which are differences of ignition propensities. The individual results also provide additional background information that is lost in the comparisons. The comparisons of the various test conditions, however, directly answer the main questions of interest.

Since the response variables (*i.e.*, ignition or non-ignition, full-length burning or not) observed in each of the individual experiments addressed here are binary, use of a binomial-distribution-based model for the data is appropriate. The primary assumptions are (a) that the binary outcome for each measurement from each potentially different population occurs with a particular fixed probability, p_i , and (b) that the outcome of each measurement is independent of the outcomes of all of the other measurements. Observations that meet these assumptions are said to be “independent and identically distributed.”

The typical confidence interval used to estimate binomial proportions, in this case relative ignition propensities, is based on the normal distribution and has lower and upper endpoints defined respectively by¹⁴

$$p_L = \frac{(2n\hat{p} + z_{\alpha/2}^2 - 1) - z_{\alpha/2} \sqrt{z_{\alpha/2}^2 - (2 + 1/n) + 4\hat{p}(n(1 - \hat{p}) + 1)}}{2(n + z_{\alpha/2}^2)}$$

and

$$p_U = \frac{(2n\hat{p} + z_{\alpha/2}^2 + 1) + z_{\alpha/2} \sqrt{z_{\alpha/2}^2 - (2 - 1/n) + 4\hat{p}(n(1 - \hat{p}) - 1)}}{2(n + z_{\alpha/2}^2)}$$

where n is the number of mock-up or extinction tests done under a particular set of conditions, \hat{p} is the proportion of tests in which an ignition or a full-length burn occurred for the Mock-up or Extinction Tests respectively, and $z_{\alpha/2}$ is the upper-tailed critical value from a standard normal distribution (*i.e.*, 1.96 for a confidence level of 95 % or $\alpha = 0.05$).

The typical confidence interval used to compare binomial probabilities from different populations, in this case relative ignition propensities of different cigarettes under different test conditions, is also based on the normal distribution.¹⁴ It has lower and upper endpoints defined respectively by

$$d_L = (\hat{p}_1 - \hat{p}_2) - z_{\alpha/2} \sqrt{\frac{\hat{p}_1(1 - \hat{p}_1)}{n_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{n_2}} - \frac{1}{2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)$$

and

$$d_U = (\hat{p}_1 - \hat{p}_2) + z_{\alpha/2} \sqrt{\frac{\hat{p}_1(1 - \hat{p}_1)}{n_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{n_2}} + \frac{1}{2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)$$

¹⁴ Fleiss, J.L., *Statistical Methods for Rates and Proportions*, John Wiley and Sons, New York, 1981.

where n_i is the number of mock-up or extinction tests done under a particular set of conditions and \hat{p}_i is the proportion of tests in which an ignition or a full-length burn occurred for the mock-up or extinction tests respectively.

Determination of whether or not an observed relative ignition propensity or a difference in the relative ignition propensities for different pairs of test conditions significantly differs from a hypothesized value with these confidence intervals simply requires checking to see if the hypothesized value falls inside or outside the interval. If the hypothesized value is in the interval then the hypothesis would not be rejected. If the hypothesized value is not in the interval then the hypothesis would be rejected.

The advantages of these confidence intervals include ease of computation and familiarity. However, they depend on the central limit theorem, which states that the distribution of \hat{p} will be approximately normal if the sample size is large. How large a sample size is required for the approximation to work well depends on the actual underlying relative ignition propensities. When either of the relative ignition propensities in question is near zero or one, very large sample sizes are required for the normal approximation to describe the behavior of the estimated ignition propensities adequately. Based on the data presented in the next section, the normal approximation would not work well for some of the comparisons of interest in this report.

As a result, different methods for estimation and comparison of the relative ignition propensities that do not depend on the applicability of the central limit theorem, but are more computationally intensive as a consequence, are used throughout this report. In the alternative procedures used here, confidence intervals are constructed numerically using the binomial distribution directly. The methods of Blyth and Still¹⁵ are used for the estimation of individual ignition propensities and the methods of Coe and Tamhane¹⁶ are used for the comparison of different ignition propensities. While requiring special software using complex algorithms, these methods provide approximate confidence intervals that are guaranteed to attain their stated confidence levels regardless of the sample sizes and true ignition propensities. In addition these methods provide intervals that will be shorter than most other methods for obtaining well-behaved, approximate confidence intervals for binomial probabilities or differences of binomial probabilities.

As for the normal-distribution intervals, for any particular comparison being made with these alternative confidence intervals statistical significance is determined by noting whether or not the confidence intervals contain a hypothesized value. For example, for the difference of two relative ignition propensities, where the natural hypothesized value is zero, the statistical significance of the difference between the ignition propensities is determined by the intervals inclusion or exclusion of zero. If the interval includes the value zero then the two ignition propensities cannot be concluded to be significantly different from one another, while if the interval does not include the value zero the appropriate conclusion is that the ignition

¹⁵ Blyth, C.R., and Still, H.A., "Binomial Confidence Intervals," *Journal of the American Statistical Association*, Vol. 78, March 1983, pp 108-116.

¹⁶ Coe, P.R., and Tamhane, A.C., "Small Sample Confidence Intervals for the Difference, Ratio and Odds Ratio of Two Success Probabilities," *Communications in Statistics, Part B -- Simulation and Computation*, Vol. 22, 1993, pp 925-938.

propensities are different. The situation for the individual confidence intervals is analogous except that there is no natural, general hypothesis of interest.

IV. RESULTS AND STATISTICAL ANALYSIS OF COMPARATIVE DATA PAIRS

A. Relative Ignition Strengths of Cigarettes 529 and 531 over Time

Table 1 shows the current data on the two experimental cigarettes and the corresponding data from the 1993 ILE of the Cigarette Extinction Method. Specifically, the NIST single-laboratory data from the ILE are included in the table.

Table 1. Relative Ignition Strengths of Cigarettes 529 and 531
(number of full-length burns/number of trials)

Cigarette	1993			2000		
	3 Layers	10 Layers	15 Layers	3 Layers	10 Layers	15 Layers
529	11/16	0/16	0/16	9/24	0/24	
531	16/16	15/16	14/16		22/24	19/24

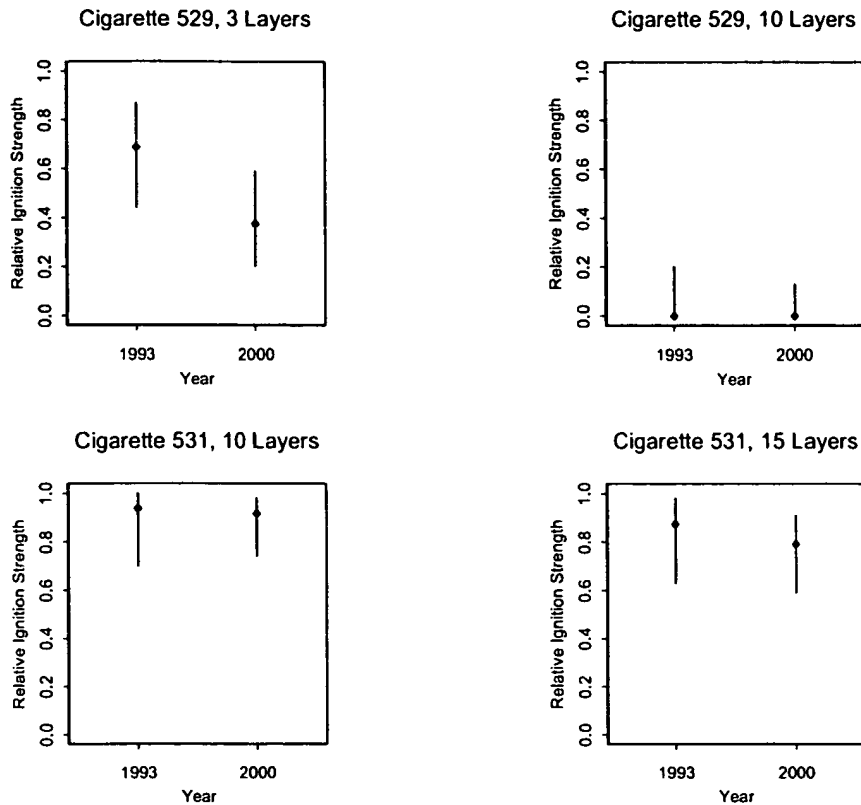
Since the Cigarette Extinction Method test procedure, the laboratory conditions, and the substrate material were the same as in the 1993 tests, and since the analysis of the 1993 ILE showed little if any dependence on the test operator, any changes observed in the relative ignition propensities of the cigarettes are attributed to the cigarettes themselves. The 95 % confidence intervals for the ignition propensity of each cigarette as measured at NIST in 1993 and in 2000 are shown in Figure 1. The large degree of overlap between the pairs of confidence intervals indicates that there is no evidence of any change in relative ignition propensity of the two laboratory cigarettes used in this comparison.

Table 2 lists approximate 95 % confidence intervals for the differences in relative ignition propensities for these two cigarettes. The fact that the confidence intervals listed in Table 2 all contain the value zero confirms the conclusion of no statistical change in the ignition propensities of these laboratory cigarettes.

Table 2. 95% Confidence Intervals for the Difference in Relative Ignition Strengths (RIS) for Cigarettes 529 and 531 over Time ($RIS_{2000} - RIS_{1993}$)

Cigarette	$RIS_{2000} - RIS_{1993}$		
	3 Layers	10 Layers	15 Layers
529	-0.56 to 0.00	-0.19 to 0.12	
531		-0.18 to 0.19	-0.30 to 0.19

Figure 1. 95% Confidence Intervals for the Relative Ignition Strengths (RIS) for Cigarettes 529 and 531 over Time



B. Similarity of New Mock-up Substrates to 1993 ILE Substrates

Table 3 shows the current data on the two experimental cigarettes with the current fabric/foam substrates, compared with the corresponding data from the NIST participation in the 1993 ILE of the Mock-up Ignition Method.

Table 3. Similarity of New Mock-up Substrates to ILE Substrates
(number of ignitions/number of trials)

Cigarette	1993			2000		
	Duck 10	Duck 6	Duck 4	Duck 10	Duck 6	Duck 4
529	18/48	6/48	0/48	4/24	0/24	
531	47/48	48/48	0/48		23/24	0/24

Since the Mock-up Ignition Method test procedure and the operational variables were the same as for the 1993 testing and since the relative ignition propensities of the cigarettes had been shown not to have changed significantly, any differences between the 1993 and 2000 test data can be attributed to changes in the susceptibility of the substrates to cigarette ignition. Figure 2

shows the 95 % confidence intervals for each substrate at each pair of times. Again, the intervals overlap substantially, indicating that there is no evidence of difference in the ignition susceptibility of the corresponding substrates. This is confirmed by all the approximate 95 % confidence intervals in Table 4 containing the value zero.

Figure 2. 95 % Confidence Intervals for the Relative Ignition Strengths (RIS) of Cigarettes 529 and 531 on Different Mock-up Test Substrates over Time

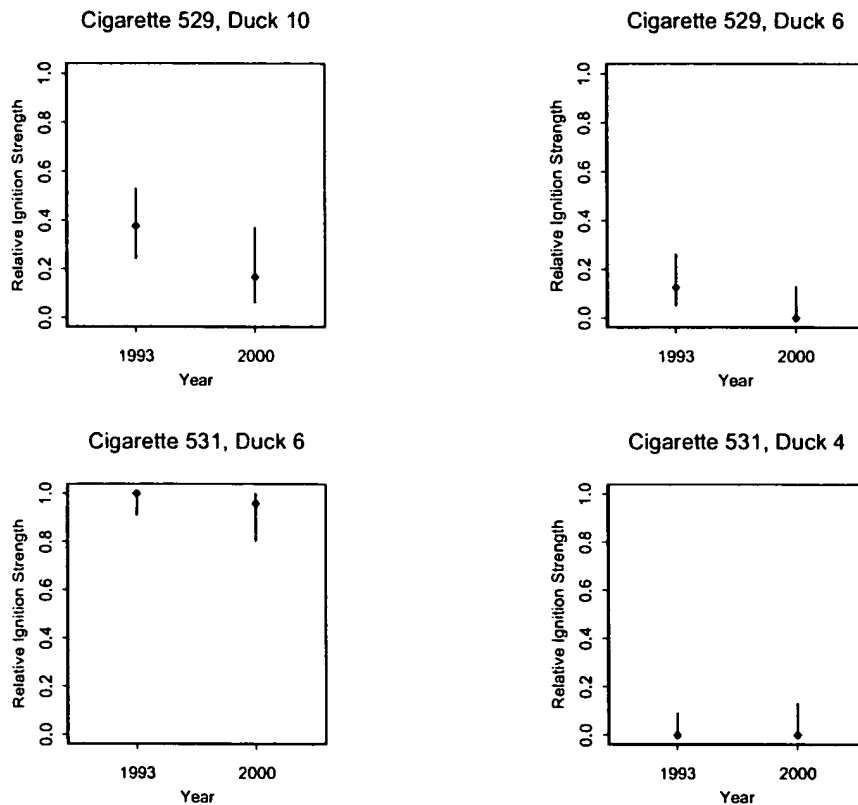


Table 4. 95 % Confidence Intervals for the Relative Ignition Strengths (RIS) of Cigarettes 529 and 531 on Different Mock-up Test Substrates ($RIS_{2000} - RIS_{1993}$)

Cigarette	$RIS_{2000} - RIS_{1993}$		
	Duck 10	Duck 6	Duck 4
529	-0.38 to 0.02	-0.23 to 0.02	
531		-0.20 to 0.02	-0.06 to 0.14

C. Relative Ignition Propensities of the Conventional and Banded Cigarettes

Having established the properties of the substrates to be used in the tests of the conventional and banded cigarettes, the next step in the analysis was to compare these two cigarettes to see if they differ in relative ignition propensity. Tables 5 and 6 show the test results.

Table 5. Ignition Propensities of Conventional and Banded Cigarettes Measured Using the Mock-up Ignition Method (number of ignitions/number of trials)

Cigarette	2000			
	Duck 10	Duck 6	Duck 4	Ivory Cot.
Conventional	32/32	32/32	6/32	32/32
Banded	12/32	16/32	1/32	19/32

Table 6. Ignition Strengths of Conventional and Banded Cigarettes Measured Using the Cigarette Extinction Method (number of full-length burns/number of trials)

Cigarette	2000		
	3 Layers	10 Layers	15 Layers
Conventional	24/24	24/24	24/24
Banded	9/24	2/24	3/24

The comparison using the Mock-up Ignition Test is shown in Figure 3 and Table 7. The 95 % confidence intervals for the ignition propensities of the two cigarettes do not overlap for three of the substrates, indicating that the conventional and banded cigarettes do differ significantly in terms of relative ignition propensity on those substrates. The conventional cigarette has a high ignition propensity on the duck #6, duck #10 and ivory cotton substrates. The banded cigarette has a lower ignition propensity across these three substrates. On the most difficult substrate to ignite, duck #4, the confidence intervals do overlap substantially. This indicates that both the conventional and banded cigarettes have similarly low relative ignition propensities on this substrate. The 95 % confidence intervals for the difference in relative ignition propensity confirm these results in that each of the confidence intervals for the duck #10, duck #6 and ivory substrates has an upper confidence bound lying below zero. This indicates that all plausible values for the relative ignition propensity of the banded cigarettes are less than the plausible values of the relative ignition propensity of the conventional cigarettes. For duck #4 the confidence interval for the difference in relative ignition propensities just includes the value zero, indicating that the two cigarettes have a small range of plausible values for their ignition propensities in common.

The relative ignition propensities measured for the ivory cotton fabric substrate are not distinguishable from the values measured for the substrates containing cotton ducks #6 and #10. While the areal density of the ivory cotton fabric is in the range that industry data indicated could show reversals (relative to the cotton duck substrates) in the ranking of cigarette ignition propensity, no such reversal was found for this fabric.

Figure 3. 95 % Confidence Intervals for the Relative Ignition Strengths (RIS) of Conventional and Banded Cigarettes on Different Mock-up Test Substrates

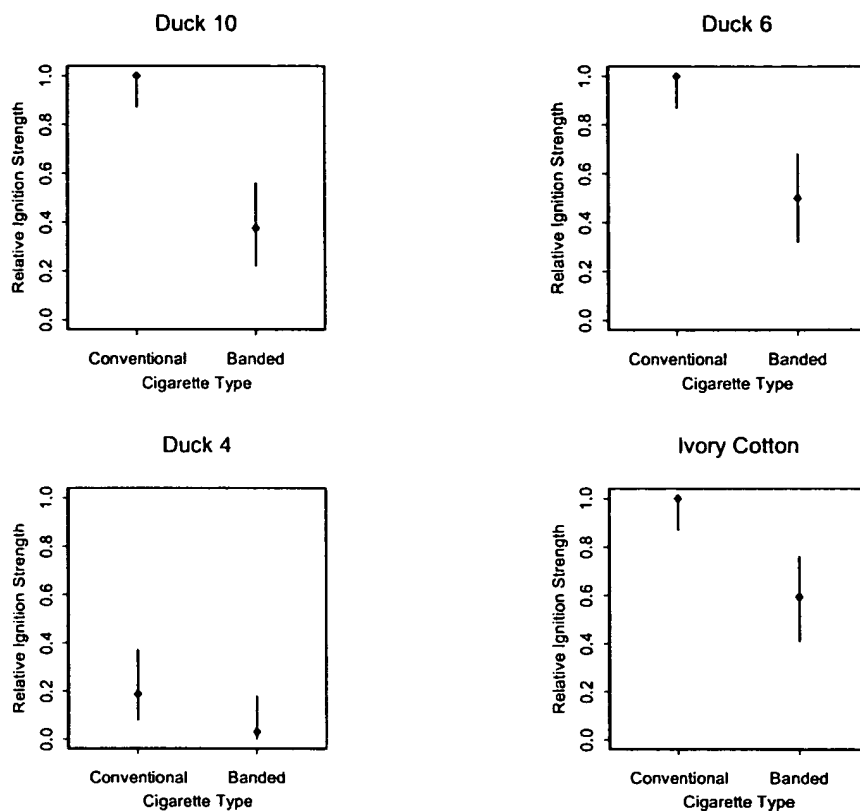


Table 7. 95 % Confidence Intervals for the Difference in Relative Ignition Strengths of Conventional and Banded Cigarettes on Different Mock-up Test Substrates ($RIS_{\text{Banded}} - RIS_{\text{Conventional}}$)

$RIS_{\text{Banded}} - RIS_{\text{Conventional}}$			
Duck 10	Duck 6	Duck 4	Ivory Cot.
-0.77 to -0.41	-0.66 to -0.31	-0.31 to 0.00	-0.57 to -0.23

The results of the comparison of the standard and banded cigarettes using the Extinction Test are shown in Figure 4 and Table 8. The interpretation of the plots in Figure 4 and the confidence intervals in Table 8 is similar to those for the Mock-up Ignition Test. In the case of the Extinction Test, however, the modified cigarette showed a significantly lower relative ignition propensity than the conventional cigarette on *all* substrates.

Figure 4. 95 % Confidence Intervals for the Relative Ignition Strengths (RIS) of Conventional and Banded Cigarettes on Different Extinction Test Substrates

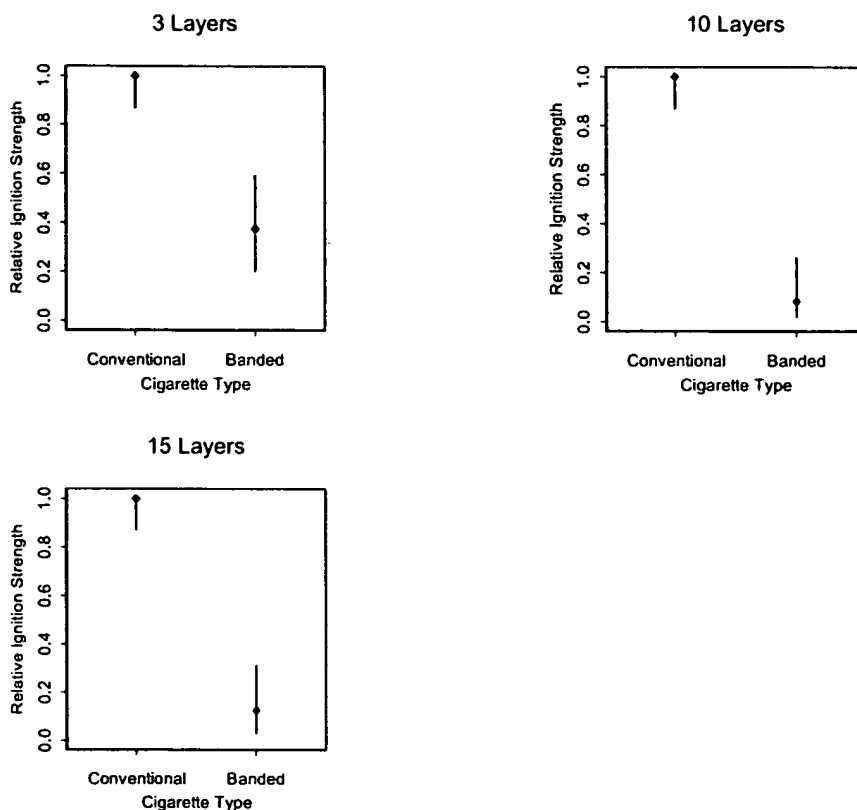


Table 8. 95 % Confidence Intervals for the Difference in Relative Ignition Strengths of Conventional and Banded Cigarettes on Different Extinction Test Substrates ($RIS_{\text{Banded}} - RIS_{\text{Conventional}}$)

$RIS_{\text{Banded}} - RIS_{\text{Conventional}}$		
3 Layers	10 Layers	15 Layers
-0.79 to -0.38	-0.98 to -0.69	-0.97 to -0.64

V. DISCUSSION

The above analysis shows that the banded cigarettes produced significantly fewer failures in both test methods than did their conventional counterparts. Table 9 puts these results in context with the data from reference 9. The 14 best-selling commercial cigarettes in 1993 ignited the mock-ups or burned their full length on filter paper in virtually every test. [The results for one of these cigarettes are shown in the first row.] Cigarettes A through F are other 1993 commercial cigarettes that were expected, based on values of their physical properties, to have reduced

ignition propensities. The five numbered cigarettes are those experimental cigarettes used in the ILE of the two test methods.

Table 9. Percent Ignitions or Full Length Burns on Test Method Substrates [Prior data from reference 9]

SUBSTRATE → CIGARETTE ↓	3 layers	Duck #10	10 layers	Duck #6	15 layers	Duck #4
1993 Commercial	100	100	100	100	100	100
B	100	100	100	92	94	73
503	100	100	100	100	100	53
Conventional	100	100	100	100	100	19
501	100	100	100	100	100	11
D	100	100	94	73	88	46
E	100	100	100	96	94	0
531	99	98	94	95	88	0
A	100	100	94	92	38	4
F	100	100	100	79	19	0
529	57	30	6	8	2	0
Banded	39	37	8	50	12	3
530	6	3	0	0	0	0

Cigarettes 531 and 529 differ in the air permeability of the wrapping paper. The same is true of the conventional and banded cigarettes, although the permeability difference is only in the banded regions. There is a similarity in performance between the 531 and the conventional cigarette, with nominally 100 % failures on five of the six substrates. The 529 and banded cigarette show similar and significant improvements on those five substrates, as well as large differences from the 1993 best-selling cigarettes. For the #4 cotton duck substrate, the most difficult to ignite, the conventional cigarette caused relatively few ignitions, leaving no room for the banded version to show improvement.

VI. CONCLUSION

As requested by the Federal Trade Commission staff, NIST has measured the ignition propensity of a test market cigarette made with slower burning paper relative to the performance of the unmodified product. Analysis of the test data shows that the banded cigarette has a lower relative ignition propensity than its conventional counterpart.

APPENDIX A. Request Letter of May 15, 2000, from the Federal Trade Commission to the National Institute of Standards and Technology



UNITED STATES OF AMERICA
FEDERAL TRADE COMMISSION
WASHINGTON, DC 20580

Bureau of Consumer Protection

May 15, 2000

Dr. Jack E. Snell
Director
Building and Fire Research Laboratory
Mail Stop 8600
National Institute of Standards and Technology
100 Bureau Drive
Gaithersburg, MD 20899-8600

Dear Dr. Snell:

It is my understanding that the National Institute of Standards and Technology ("NIST") is able to conduct tests to determine the relative likelihood of ignition of different types of cigarettes, and would be willing to conduct such tests upon request by the Federal Trade Commission. Philip Morris, Inc. recently announced publicly its plans to test market a cigarette made with a slower burning paper that would reduce the risk that a dropped or discarded cigarette will start a fire.¹ It would greatly assist the Commission in its responsibilities over tobacco products if NIST would conduct tests to determine whether and to what extent this cigarette does reduce the risk of ignition. Thus, I am requesting that NIST perform such tests as needed to evaluate this cigarette.

Thank you very much for your assistance. If you have any questions, please call Rosemary Rosso at (202) 326-2174.

Sincerely,

A handwritten signature in black ink that reads "Jason Z. Bernstein".
Jason Z. Bernstein
Director

Bureau of Consumer Protection

cc: Dr. Richard G. Gorn

¹ See "Philip Morris Plans Slow-Burn Paper," www.nytimes.com/aprd/mc/13/13A2-Slow-Burn.html (Jan. 13, 2000).

APPENDIX B. Reply Letter of May 19, 2000, from the National Institute of Standards and Technology to the Federal Trade Commission.



UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

May 19, 2000

Ms. Joan Z. Bernstein
Director, Bureau of Consumer Protection
Federal Trade Commission
Washington, D.C. 20580

Dear Ms. Bernstein:

Thank you for your letter requesting that the National Institute of Standards and Technology (NIST) use its expertise to determine the relative likelihood of ignition of soft furnishings by the new cigarettes of Philip Morris, Inc. While NIST does not routinely perform product tests, we recognize the important role of the Federal Trade Commission in assuring the public of the veracity of product claims and the high potential for less fire-prone cigarettes to reduce fire deaths and injuries. We thus agree to measure the ignition propensity of these test cigarettes relative to the performance of the unmodified product. Note that this is not an absolute measure of ignition probability in real circumstances, but is a strong indicator as to whether a reduction in cigarette-initiated fires might be expected.

We should be able to complete our work and transmit a report to you within 5 months. After no more than a short delay, we would expect the report to become public.

Dr. Richard Gann [phone: (301) 975-6866, rggann@nist.gov] will be our point of contact to work with Ms. Rosso on this matter.

Sincerely,


Jack E. Snell, Director
Building and Fire Research Laboratory

cc: Richard Gann
Raymond Kammer
Michael Rubin
Matthew Heyman
Rosemary Russo

NIST

APPENDIX C. MOCK-UP IGNITION METHOD

This test method measures the probability that a lit cigarette, placed on one of three standardized upholstery mock-ups, will ignite the mock-up to smoldering combustion. The mock-ups consist of a sheet of fabric over a block of flexible polyurethane foam. One substrate has a sheet of plastic film between the fabric and the foam to increase the overall thermal mass. A number of replicate tests (composing a trial) are performed to obtain the relative probability that the cigarette will ignite the substrate. Four of these apparatus were used concurrently.

1. Apparatus and Equipment

An environmental conditioning room provided an area adequate for conditioning both cigarettes and filter paper specimens. This room was maintained at a relative humidity of $55 \% \pm 5 \%$ and a temperature of $23^{\circ}\text{C} \pm 3^{\circ}\text{C}$ and was continuously monitored.

A test chamber of the design photographed in Figures C-1 and C-2 was used for testing the cigarette/substrate combinations.

A square brass rim, shown in Figure C-2 was used to hold the fabric (and film) flat against each other and the foam. The outside dimension of the rim was $200 \text{ mm} \pm 2 \text{ mm}$. The inner dimension was $150 \text{ mm} \pm 2 \text{ mm}$. The thickness was $3 \text{ mm} \pm 1 \text{ mm}$. The rim surface was flat and smooth.

A cylindrical holder supported the cigarette in the test chamber prior to placement onto the filter paper substrate. The cylinder was of a length and diameter to support the cigarette in a vertical position, coal side up, without damaging the cigarette. The base plate for the cylinder was just under 50 mm in diameter, and the holder weighed less than 70 g.

A butane gas lighter capable of producing a stable luminous flame for approximately 15 mm in length was used for lighting the cigarette. The cigarette was supported in a horizontal position, with an airflow through the cigarette of 15 mL/s - 20 mL/s. The draw time through the lit cigarette was sufficient to establish a coal equal to or less than 5 mm in length. Filtering media were used downstream of the cigarette to remove smoke and condensable combustion gases in order to prevent contamination of the downstream components.

A chemical or canopy hood removed combustion products from the test room. Airflow through the hood was sufficient to remove cigarette and substrate combustion products while not being high enough to influence the combustion processes in the test chamber(s).

Following a test, the cigarette and substrate materials were completely extinguished with a small stream of water.

2. Calibration and Standardization

Calibrations of equipment were carried out at regular intervals and at any time when equipment or test conditions indicate that evaluation and re-calibration were necessary.

The ignition test chambers were checked before use to insure that the front door seals properly and that air movement in the test area does not introduce transient air movement in the test chambers. Door seals were checked visually to ensure that they closed flush against the chamber's side wall and the latching device secured the door tightly. All construction seams were inspected to ensure they were airtight, with no cracks visible on any surface of the test chamber.

The stability of the air inside each test chamber was determined daily by placing a lit cigarette in the test position on one or more layers of filter paper, then closing the chamber door. Smoke being emitted by the cigarette rose vertically and showed no turbulence within 150 mm above the lit end of the cigarette.

The humidity and temperature sensors used to record environmental conditions in the conditioning room or the chamber and test room were checked for accuracy daily.

The air draw apparatus used for igniting cigarettes was calibrated at the beginning and end of this project.

3. Test Specimens and Standard Substrate Assemblies

Cigarette test specimens were protected from physical or environmental damage while in handling and storage. Clean plastic gloves were worn at all times to minimize contamination of the cigarette test specimens and filter paper substrates, which are sensitive to contamination. If the specimens were to be stored for more than one week, they were placed in a freezer reserved for the sole protection of cigarette specimens.

Prior to testing, cigarette test specimens were marked on their paper seam 5 mm and 15 mm from the tobacco end with a #2 graphite pencil. These marks are used to establish a uniform burn and the start of the coal respectively.

The substrate materials were as follows:

The open-cell, non-fire-retarded flexible polyurethane foam had been cut into blocks 200 mm \pm 5 mm square and 50 mm \pm 2 mm thick. The foam density was 32 kg/m³ \pm 3 kg/m³ and the air permeability was 1.9 x 10⁻³ m³/s \pm 0.1 x 10⁻³ m³/s.

Three standard test fabrics were used, having the following nominal properties:

100 % Cotton Duck	Areal Density (kg/m²)	Yarn Count (per inch)	Yarn Plies	Air Permeability (10⁻³ m³s⁻¹m⁻²)
#4	0.83	31 x 24	4 x 4	5.1 to10.2
#6	0.72	36 x 26	3 x 3	5.1 to10.2
#10	0.50	40 x 28	2 x 2	10.2 to20.4

A fourth 100 % cotton fabric had an areal density of 0.36 kg/m².

The polyethylene film used with the #4 cotton duck substrates had a thickness of 0.15 mm ± 0.007 mm and an areal density of 0.012 kg/m² ± 0.005 kg/m².

The substrates were formed by placing the fabric (and film) on the foam, then placing the metal rim on top to ensure good contact between the layers.

4. Conditioning

The cigarettes were conditioned at a relative humidity of 55 % ± 5 % and a temperature of 23 °C ± 3 °C for at least 24 hours prior to ignition testing. The cigarettes were stored vertically, filter end up, in a clean 250 mL glass beaker, with a maximum of 20 cigarettes per beaker to enable free air access to the specimens.

The substrate materials were also conditioned at a relative humidity of 55 % ± 5 % and a temperature of 23 °C ± 3 °C for at least one week prior to ignition testing.

5. Procedure

Turn on the exhaust system designated for removal of test combustion products 30 min prior to beginning testing.

Cover the chimney on the test chamber.

Select the substrate materials for the scheduled test. Place the assembly in the test chamber at the geometric center of its bottom and place the metal test rim on top.

Place the cigarette holder on the center of the fabric.

Without delay, remove a cigarette from the conditioned space. Insert the unmarked end of the cigarette into the cigarette ignition system and hold it in a horizontal position. Turn on the air draw, verifying that the air flow is 15 mL/s to 20 mL/s. Hold the ignition flame or hot wire coil to the marked end of the cigarette for as long as is necessary to achieve uniform ignition without passing the 5 mm mark.

Holding the cigarette vertically, coal end up and under a 600 mL beaker, transport the cigarette to the test chamber.

Place the lit cigarette, still vertical, in the cigarette holder.

Simultaneously close the door and remove the chimney cover.

If the cigarette should self-extinguish while in the cigarette holder, terminate the test and record the results as a self-extinguishment and note that this occurred in the holder.

When the cigarette has burned to the 15 mm mark, simultaneously replace the chimney cover and open the chamber door, gently remove the cigarette from the holder, and move the holder to the front corner of the test chamber.

Gently lay the cigarette with the ash still attached onto the top of the fabric so that the coal end is located at the geometric center of the surface and the cigarette axis is diagonal to the fabric warp. The cigarette paper seam is turned up. Do not drop the cigarette onto the fabric and do not press the coal into the fabric. If the ash falls off during any part of the transport or positioning process, terminate the test and begin again; do not count the attempt.

Without delay, simultaneously remove the chimney cover and gently close the door.

Observe the burning cigarette. The smoke plume near the cigarette must remain undisturbed. If it does not, this observation shall be noted on the test sheet.

Record the following results:

- (1) Ignition: the char mark on the fabric propagates at least 10 mm from the edge of the cigarette;
- (2) Non-ignition: the tobacco column burns to the end without causing an ignition; or
- (3) Self-extinguishment: the coal goes out before the tobacco column is consumed.

Extinguish the cigarette and the substrate materials using a water bottle.

Open the test chamber door to allow air to circulate throughout its volume. After the chamber has cleared, prepare for the next test.

Repeat the test with each cigarette the requisite number of times per trial. Calculate the percentage of tests in which the cigarettes burned their full length.

6. Test Report

Report the following information for each test:

Name of person performing the test
The temperature and relative humidity in the laboratory
Date of each test
Cigarette identification
The fabric type and sample number
The sample number for the foam block and plastic film
The outcome of the test

For each trial, report the percentage of tests in which the cigarettes ignited the substrates.

Figure C-1. Photograph of Test Chamber and Cigarette on Mock-up Assembly

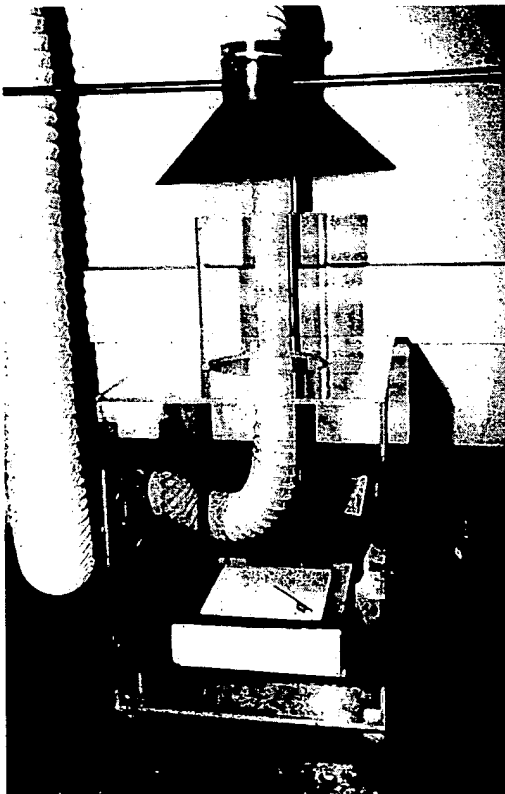
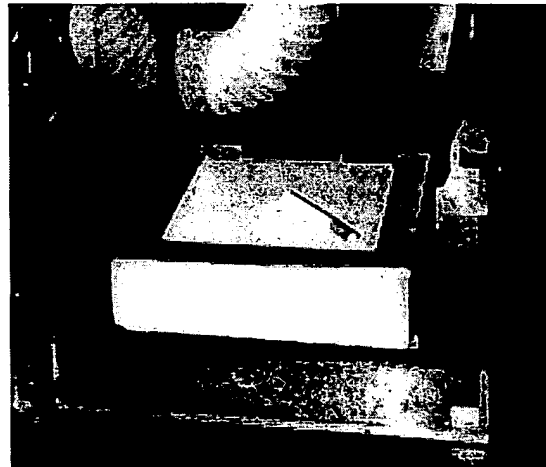


Figure C-2. Close-up of Cigarette on Mock-up Assembly with Square Frame in Place



APPENDIX D. CIGARETTE EXTINCTION METHOD

This test method measures the probability that a cigarette, placed on a substrate, will generate insufficient heat to maintain burning of the tobacco column. Each test consists of placing a lit cigarette on the horizontal surface consisting of a set number of layers of filter paper.

Observation is made of whether or not the cigarette continues to burn the full length of the tobacco column. A number of replicate tests (composing a trial) are performed to obtain the relative probability that the cigarette will be extinguished by heat abstraction by the substrate. Four of these apparatus were used concurrently.

7. Apparatus and Equipment

An environmental conditioning room provided an area adequate for conditioning both cigarettes and filter paper specimens. This room was maintained at a relative humidity of $55\% \pm 5\%$ and a temperature of $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ and was continuously monitored.

A test chamber of the design photographed in Figures D-1 and D-2 was used for testing the cigarette/substrate combinations.

A cylindrical support for the layers of filter paper, shown in Figure D-2, was of PMMA and dimensioned as follows: outer diameter of $165 \pm 1\text{ mm}$, inner diameter of $127\text{ mm} \pm 1\text{ mm}$, and a height of $50\text{ mm} \pm 1\text{ mm}$. A recess in the top, $8 \pm 1\text{ mm}$ deep, expanded the inner diameter to $152\text{ mm} \pm 1\text{ mm}$. Three or four legs raised the bottom of the holder approximately 20 mm above the chamber floor.

A circular brass or similar metal rim, shown in Figure D-2 was used to hold the sheets of filter paper flat against each other. The outside diameter of the rim was $150\text{ mm} \pm 2\text{ mm}$. The inner diameter was $130\text{ mm} \pm 2\text{ mm}$. The thickness was $3\text{ mm} \pm 1\text{ mm}$. The rim surface was flat and smooth. A pair of parallel metal pins, each approximately 1 mm in diameter and $8.1\text{ mm} \pm 0.05\text{ mm}$ apart, protruded approximately 20 mm toward the center of the rim, spaced to keep the filter end of a conventional 25 mm circumference cigarette from rolling, but without pressuring the filter. When cigarettes of significantly different diameter were tested, other pairs of pins, appropriately spaced, were inserted into the rim.

A cylindrical holder supported the cigarette in the test chamber prior to placement onto the filter paper substrate. The cylinder was of a length and diameter to support the cigarette in a vertical position, coal side up, without damaging the cigarette. The base plate for the cylinder was just under 50 mm in diameter, and the holder weighed less than 70 g.

A butane gas lighter capable of producing a stable luminous flame for approximately 15 mm in length was used for lighting the cigarette. The cigarette was supported in a horizontal position, with an air flow through the cigarette of 15 mL/s to 20 mL/s. The draw time through the lit cigarette was sufficient to establish a coal equal to or less than 5 mm in length. Filtering media were used downstream of the cigarette to remove smoke

and condensable combustion gases in order to prevent contamination of the downstream components.

A chemical or canopy hood removed combustion products from the test room. Airflow through the hood was sufficient to remove cigarette and substrate combustion products while not being high enough to influence the combustion processes in the test chamber(s).

Following a test, the cigarette and sheets of filter paper were completely extinguished.

8. Calibration and Standardization

Calibrations of equipment were carried out at regular intervals and at any time when equipment or test conditions indicated that evaluation and re-calibration were necessary.

The ignition test chambers were checked before use to insure that the front door seals properly and that air movement in the test area does not introduce transient air movement in the test chambers. Door seals were checked visually to ensure that they closed flush against the chamber's side wall and the latching device secured the door tightly. All construction seams were inspected to ensure they were airtight, with no cracks visible on any surface of the test chamber.

The stability of the air inside each test chamber was determined daily by placing a lit cigarette in the test position on one or more layers of filter paper, then closing the chamber door. Smoke being emitted by the cigarette rose vertically and showed no turbulence within 150 mm above the lit end of the cigarette.

The humidity and temperature sensors used to record environmental conditions in the conditioning room or the chamber and test room were checked for accuracy daily.

The air draw apparatus used for igniting cigarettes was calibrated at the beginning and end of this project.

9. Test Specimens and Standard Substrate Assemblies

Cigarette test specimens were protected from physical or environmental damage while in handling and storage. Clean plastic gloves were worn at all times to minimize contamination of the cigarette test specimens and filter paper substrates, which are sensitive to contamination. If the specimens were to be stored for more than one week, they were placed in a freezer reserved for the sole protection of cigarette specimens.

Prior to testing, cigarette test specimens were marked on their paper seam 5 mm and 15 mm from the tobacco end with a #2 graphite pencil. These marks are used to establish a uniform burn and the start of the coal respectively.

The filter paper substrates consisted of 150 mm diameter circles of Whatman #2 filter paper. They were formed by placing multiple layers of filter paper into the holder assembly, then placing the metal rim on top to ensure good contact between the layers.

10. Conditioning

The cigarettes were conditioned at a relative humidity of $55 \% \pm 5 \%$ and a temperature of $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ for at least 24 hours prior to ignition testing. The cigarettes were stored vertically, filter end up, in a clean 250 mL polyethylene or glass beaker, with a maximum of 20 cigarettes per beaker to enable free air access to the specimens.

Filter papers were conditioned at a relative humidity of $55 \% \pm 5 \%$ and a temperature of $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ for at least 24 hours prior to ignition testing. Individual papers were supported side-by-side in racks that held each piece vertically on edge and maintained air spaces between the individual sheets. Small fans located *ca.* 100 mm above the tops of the sheets provided gentle downward air circulation.

11. Procedure

Turn on the exhaust system designated for removal of test combustion products 30 min prior to beginning testing.

Ensure that the filter paper holder is in the test chamber at the geometric center of its bottom. Cover the chimney on the test chamber.

Select the number of layers of filter paper for the scheduled tests. Immediately before testing, place the proper number of filter papers on the filter paper holder and place the metal test rim on top. Do not use filter papers that will not lay flat.

Place the cigarette holder on the center of the filter papers.

Without delay, remove a cigarette from the conditioned space. Insert the unmarked end of the cigarette into the cigarette ignition system and hold it in a horizontal position. Turn on the air draw, verifying that the air flow is 15 mL/s to 20 mL/s. Hold the ignition flame to the marked end of the cigarette for as long as is necessary to achieve uniform ignition without passing the 5 mm mark.

Holding the cigarette vertically, coal end up and under a 600 mL beaker, transport the cigarette to the test chamber.

Place the lit cigarette, still vertical, in the cigarette holder.

Simultaneously close the door and remove the chimney cover.

If the cigarette should self-extinguish while in the cigarette holder, terminate the test and record the results as a self-extinguishment and note that this occurred in the holder.

When the cigarette has burned to the 15 mm mark, simultaneously replace the chimney cover and open the chamber door, then gently remove the cigarette from the holder, and move the holder to the front corner of the test chamber.

Gently lay the cigarette with the ash still attached onto the top of the filter papers so that the "filter" end is placed between the appropriately sized cigarette anti-roll fingers. The cigarette paper seam is turned up. Do not drop the cigarette onto the filter papers and do not press the coal into the papers. If the ash falls off during any part of the transport or positioning process, terminate the test and begin again; do not count the attempt.

Without delay, simultaneously remove the chimney cover and gently close the door.

Observe the burning cigarette. The smoke plume near the cigarette must remain undisturbed. If it does not, this observation shall be noted on the test sheet.

Record the following results:

- (1) The cigarette burns the full length of the tobacco column or
- (2) The burning ceases before reaching the end of the tobacco column.

Ensure that neither the cigarette nor the filter papers are still burning.

Open the test chamber door to allow air to circulate throughout its volume. After the chamber has cleared, prepare for the next test.

Repeat the test with each cigarette the requisite number of times per trial. Calculate the percentage of tests in which the cigarettes burned their full length.

12. Test Report

Report the following information for each trial:

- Name of person performing the test
- The temperature and relative humidity in the laboratory
- Date of each test
- Cigarette identification
- Number of layers of filter paper per test
- The percentage of tests in which the cigarettes burned their full length

Figure D-1. Photograph of Test Chamber and Filter Paper Holder

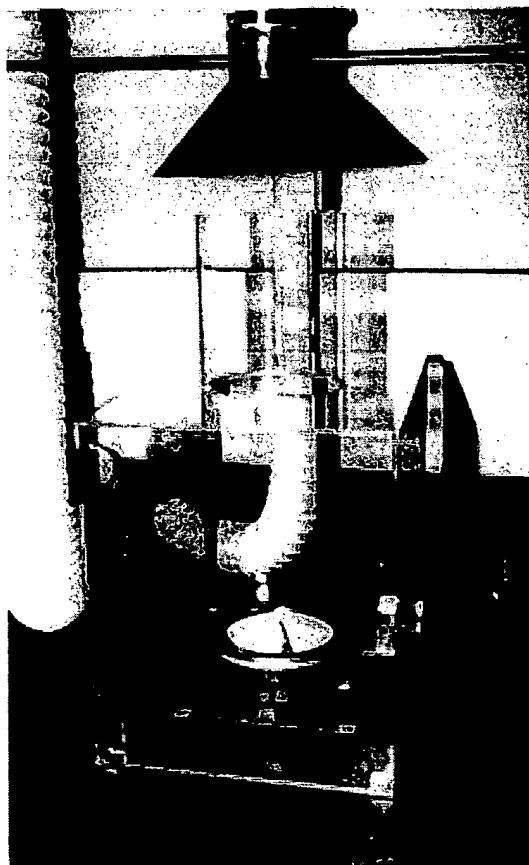
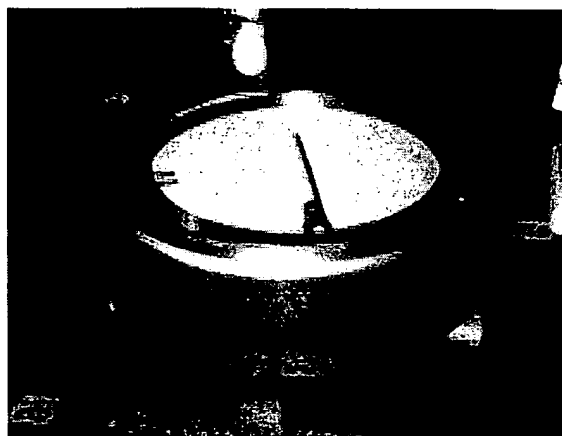


Figure D-2. Close-up of Filter Paper Holder and Metal Rim



APPENDIX E. MEASUREMENT OF CIGARETTE PAPER BANDS

(Work performed by Jiann C. Yang, NIST)

Two samples of the banded paper were obtained by removing the filters and tobacco from two cigarettes. The curled papers were straightened by placing them between two glass slides overnight. The papers were placed in a 35 mm film and negative holder and digitized using a slide scanner (Microtek ScanMaker 35t). The width of the paper band and the distance between the two adjacent bands were obtained by enhancing (histogram stretching) and analyzing the digital images using image analysis software (SigmaScanPro 4.0). Spatial calibration was obtained by scanning a Leica 2 mm micrometer mounted on a glass slide. The uncertainty associated with the calibration micrometer is ± 1 pixel (0.02 mm). For each paper sample, 10 random measurements were made along the width of the band and the distance between the two bands.

Table E-1. Measurement of Band Width and Band Separation

Cigarette paper 1				Cigarette paper 2			
Width (pixels)	Width (mm)	Separation (pixels)	Separation (mm)	Width (pixels)	Width (mm)	Separation (pixels)	Separation (mm)
272	5.79	1016	21.62	309	6.58	936	19.92
264	5.62	1024	21.79	309	6.58	938	19.96
262	5.58	1000	21.28	308	6.55	934	19.87
272	5.79	1016	21.62	311	6.62	936	19.92
270	5.75	1016	21.62	308	6.55	936	19.92
266	5.66	1012	21.53	310	6.60	942	20.04
272	5.79	1012	21.53	308	6.55	940	20.00
273	5.81	1008	21.45	309	6.58	932	19.83
262	5.58	1020	21.70	310	6.60	936	19.92
266	5.66	1004	21.36	310	6.60	938	19.96
	5.70 \pm 0.09 mean \pm std		21.55 \pm 0.15 mean \pm std		6.58 \pm 0.03 mean \pm std		19.93 \pm 0.06 mean \pm std
Calibration factor: 2 mm = 47 pixels							

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APPENDIX B

**“The Effect of Cigarette Characteristics on the Ignition of
Soft Furnishings”**

3

Technical
Study Group
Cigarette Safety
Act of 1984

**The Effect of
Cigarette Characteristics
on The Ignition
of Soft Furnishings**

October 1987

RICHARD G. GANN
RICHARD H. HARRIS, JR.
JOHN F. KRASNY
ROBERT S. LEVINE
HENRI E. MITLER
THOMAS J. OHLEMILLER

Center for
Fire Research
National Bureau
of Standards

Contents

List of Figures and Tables	iii
Executive Summary	1
Section 1:	5
Introduction	9
Project Background	9
Nature of This Project	10
References for Section 1	11
Section 2: Materials	13
Cigarettes	17
Description of Cigarettes	17
Series 1 Experimental Cigarettes	17
Series 2 Experimental Cigarettes	17
Patented, Low Ignition Propensity Cigarettes	17
Commercial Cigarettes	20
Quality Assurance of Cigarettes	20
Methods for the Determination of Cigarette Characteristics	20
Results of Measurements of Physical and Chemical Characteristics of Cigarettes	20
Series 1 Experimental Cigarettes	20
Series 2 Experimental Cigarettes	22
Substrates	29
Fabrics	29
Padding	29
Mockup Configurations	29
Chairs	31
References for Section 2	32
Appendix 2-A	33
Appendix 2-B	39
Appendix 2-C	43
Appendix 2-D	45
Appendix 2-E	49
Appendix 2-F	51
Appendix 2-G	53
Section 3: Performance Measurements	55
Introduction	59
Bench-Scale Evaluations	61
Methods	61
Ignition Propensity Measurements	61
Contamination of Fabrics with Alkali Metal Ions and Natural Soil	61
Results and Discussion	62
Ignition Propensity Results	62
Primary Evaluation of Experimental Cigarettes for Ignition Propensity	62
Validation of Ignition Propensity Primary Evaluation Results	65
Comparison of Full-Scale Furniture and Bench-Scale Tests	71
Objective	71
Method	71
Cigarette Selection, Handling and Coding	71
Experimental Design	71
Test Procedure for Full-Scale Furniture Tests	72
General	72
Cigarette Location and Placement	72
Criteria for Ignition	73
Data from Full-Scale Tests	73
Difficulties with the Procedure	74
Conditioning of the Chairs	74
Drafts	74
Self-extinguishment of Cigarettes	74
Times to Ignition of Substrate	74
Crevice Shape	74
Influence of Substrate on Cigarette Burning	75
Results	75
Validation of Bench-Scale Tests by Full-Scale Tests	75
Validation Results Weighted by Numbers of Tests	80
Use of Kendall's Tau Correlation Coefficient to Summarize the Agreement Between Full-Scale and Bench-Scale Tests	80
Relative Ranking of Cigarettes in Full-Scale Tests and the Primary Evaluation	80
Average Per Puff Tar, Nicotine, and CO Yields of Experimental Cigarettes	81
Summary of Characteristics of Experimental, Low Ignition Propensity Cigarettes	85
Patented Cigarettes	87
Summary and Conclusions	89
References for Section 3	91
Appendix 3-A	93
Appendix 3-B	97
Section 4: Thermophysics of the Ignition Process	99

Introduction	105
Experimental Methods	107
Experimental Methods for Heat Transfer Measurement	107
Previous Work	107
Present Work	107
Experimental Methods for Measuring Oxygen Depletion in the Substrate	111
Experimental Methods for Substrate Temperature Probing	112
Results and Discussion	115
Substrate Effect on Cigarette	115
Heat Flux Scans on Various Substrates	120
Non-steadiness in the Coal Temperature	129
Oxygen Depletion in the Fabric	130
Substrate Temperatures	132
Summary and Conclusion	135
References for Section 4	137
 Section 5: Modeling Ignition	139
Introduction	145
Background	147
Cigarette Dynamics	147
Previous Modeling Efforts	148
Modeling the Substrate	151
Thermal Physics	151
Ignition	152
Possible Improvements	152
Modeling the Free Cigarette	153
Semi-Empirical Model	153
Burning Rate as a Function of Various Parameters	153
The Surface Heat Flux	154
Correlation Between v and t_c	155
Detailed Model	157
Partial Model	160
Equations	160
Numerics	161
Initial Conditions	162
Comments	162
Interactions Between Cigarette and Substrate	163
Conduction Flux to Substrate	163
Radiation Flux to the Substrate	165
Connection with the Semi-Empirical Model	165
Cigarette Energy Balance in the Presence of a Substrate	167

Summary	169
Results from Using the Models	171
Substrate Program	171
Cigarette Program	177
Summary and Conclusions; Lessons Learned	181
References for Section 5	183
Appendix 5-A: A Description of the Substrate Program	185
Appendix 5-B: The Cigarette Program CIG25	189
Appendix 5-C: Convective and Radiative Losses from a Freely Burning Cigarette	199
Appendix 5-D: Derivation of the Transverse Conductive Flux Distribution	203

Section 6: Evaluation of Test Methods for Cigarette Ignition Propensity	207
Introduction	211
Methods Suggested in the Literature	213
Weight Loss of Polyurethane Foam	215
Procedure	215
Comparison of Weight Loss Results and Number of Ignitions	215
Cigarettes Burning on an Alpha-Cellulose Substrate	219
Cigarettes Smoldering on a Glass Plate	221
Methods	221
Results	221
Tentative Test Method Using Fabrics and Padding Materials	223
General Considerations	223
Outline of Suggested Tentative Test Method	223
Summary	225
References for Section 6	227

Section 7: Conclusions	229
-------------------------------------	-----

Section 8: Priority Further Research Directions	233
Test Method Development and Baseline Data	237
Experimental Cigarette Testing	237
Baseline Performance Data	237
Broader Investigation of Ignition Physics	237
Ignition Model Predictions	238

Section 9: Acknowledgements	239
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Executive Summary

Introduction

Cigarette ignition of furniture is by far the leading cause of fire deaths and injuries in the United States. While more ignition-resistant furnishings are being manufactured, fire casualties could be more rapidly reduced if cigarettes were manufactured to cause fewer ignitions. To provide both the fundamental understanding of the cigarette/furniture ignition process and practical application of that knowledge, the Center for Fire Research of the National Bureau of Standards pursued the following fundamental and applied research tasks under the Cigarette Safety Act of 1984.

- Identify the characteristics of cigarettes that could lead to a reduction in ignition propensity (using experimental cigarettes of well-characterized composition and construction supplied by the cigarette industry);
- Obtain and analyze data to verify the composition of and statistical variation in the experimental cigarettes in order to provide a reliability analysis of laboratory findings using those cigarettes;
- Measure the ignition propensities of patented, non-commercial cigarettes, as supplied by their inventors;
- Validate the cigarette ignition propensity data from the bench-scale testing by comparison with test results, using real furniture items (supplied by the furniture industry) indicative of the most common or high risk types;
- Elucidate the thermal conditions associated with lit cigarettes, their energy transfer to various substrates, and the ensuing ignition process;
- Create a computer model of the ignition process to enable prediction of the direction and approximate magnitude of effects of variations in the characteristics of a cigarette on its ignition propensity;
- Quantify the effect of smolder-promoting alkali metal ion concentration in fabrics and paddings on their susceptibility to smoldering ignition by cigarettes to account for the effect of ignitability variations within or between lots of commercially-produced upholstery materials; and
- Develop a laboratory method for measuring the ignition propensity of cigarettes.

Approach

This research project comprised several concurrent, interactive studies. These ranged from computational to experimental, fundamental to empirical.

1. Materials

A common set of materials was used in the various laboratory experiments. Forty-one types of experimental cigarettes were specially prepared for this study by the cigarette industry. They varied in tobacco type and density, paper permeability and citrate content, and circumference. The wrappers and fillers were selected for systematic and broad property variation, not necessarily indicative of current commercial cigarettes. Laboratories expert in the appropriate measurements were commissioned to characterize the composition of and variance in these cigarettes. Five embodiments of cigarette patents were received from their inventors. Several commercial cigarettes, remaining from a prior project under the Act, were used here as well. Selected fabrics and padding materials were acquired in large quantities to allow for the numerous bench-scale and full-scale tests.

2. Performance Measurements

Ignition performance measurements of the cigarettes were carried out on substrates having a range of ignition resistance, including some which simulated the most easily-ignited furniture. At least five replicate tests were performed for each cigarette/substrate combination. The data were statistically analyzed for correlations between numbers of ignitions and the individual cigarette characteristics. Similar testing was performed on chairs manufactured of some of the same materials, and the data analyzed to determine the extent to which the results were predicted by the small-scale tests.

3. Thermophysics of the Ignition Process

The ignition process was assumed to depend on the energy transfer from cigarettes to furniture items. This was studied using fine thermocouples and a heat flux gauge to follow the temperature and energy flux histories while cigarettes smoldered on different substrates. Two-dimensional infrared imaging radiometry was used to map the thermal response of the substrate. Graphical correlations were explored between measured properties of the burning cigarettes and the measured ignition propensities.

4. Modeling Ignition

Both fundamental and semi-empirical mathematical modeling of the lit cigarette and ignition of the substrate were pursued. Each borrowed heavily from prior efforts elsewhere. A comprehensive list of the involved materials properties and physical processes was compiled. Substantial simplifications were made in representing these. The predictions from the resulting FORTRAN programs were tested, to a limited extent, against the trends observed in the laboratory tests.

Table ES-1. Ignition Propensities of Selected Test Cigarettes

	<u>Designation</u>	<u>No. Ignitions 20 Tests</u>	<u>%</u>
Experimental Cigarettes	201	0	0
	106	1	5
	202	2	10
	130	4	20
	114	4	20
	105	6	30
	113	6	30
	108	7	35
	122	7	35
	129	10	50
Least Ignition-Prone Commercial Cigarettes	1	16	80
	2	12	60
Typical Ignition Propensity Commercial Cigarettes	3	18	90
	6	20	100

5. Effects of Materials Treatment

Fabrics were treated with known concentrations of alkali metal chlorides and tested for changes in cigarette ignition resistance. Similar comparative tests were performed on clean fabrics, to which was added soil extracted from used fabrics.

6. Test Method Development

Finally, the experience and knowledge gained from the above research were applied to the task of developing a convenient, accurate test method for cigarette ignition propensity. Several previously-suggested and new approaches were analyzed and tested in the laboratory, but the development of a viable test method has not yet been completed.

Table ES-2. Ignition Propensity as a Function of Experimental Cigarette Characteristics

<u>Cigarette Parameters</u>	<u>Number of Ignitions/Tests</u>	<u>%</u>
Tobacco Packing Density		
High	282/320	88
Low	153/320	48
Cigarette Circumference (mm)		
25	243/320	76
21	192/320	60
Paper Permeability		
High	256/320	80
Low	179/320	56
Paper Citrate Conc. (%)		
0.8	231/320	72
0	204/320	64
Paper Citrate (%) (Low Ignition Propensity Cigarettes)		
0.8	47/100	47
0.0	23/100	23
Tobacco Type		
Flue-cured	222/320	69
Burley	213/320	66

Conclusions

Substantial progress has been made in understanding how to study cigarette ignition, the nature of the cigarette ignition process, and the effects of cigarette characteristics on both the thermal physics and the observed ignition of furniture.

The principal findings of this research are as follows.

- In furniture mock-up tests involving a wide range of fabrics and paddings, the best of the experimental cigarettes tested had considerably lower ignition propensities than commercial cigarettes.
- Three cigarette characteristics were found to reduce ignition propensity significantly: low tobacco density, reduced circumference, and low paper permeability. Considerably larger reductions were achieved with combinations of these. The tobacco column length, the presence of a filter tip, and citrate content of the paper had effects in limited cases. The tobacco blend had minimal impact on ignition propensity.
- Non-ignitions were often achieved without the cigarettes self-extinguishing during the test; i.e., many cigarettes burned their full length without igniting the substrate.
- Some of the best-performing experimental cigarettes had average per puff tar, nicotine, and CO yields comparable to or only slightly greater than typical commercial cigarettes.
- Each of five patented cigarette modifications also showed reduced ignition propensity over cigarettes that were identical except for the patented feature. These included varia-

Table ES-3. Average Per Puff Smoke Component Yields from Selected Cigarettes

Experimental Cigarettes	Tar (mg)	Nicotine (mg)	CO (mg)
105	1.6	0.09	1.9
106	1.8	0.10	2.0
108	1.3	0.09	1.1
113	2.4	0.19	2.2
114	2.6	0.21	2.1
122	2.4	0.15	2.4
130	2.5	0.20	2.2
201	2.5	0.18	2.5
202	2.0	0.16	2.4
Average for 6 Most Popular Commercial Cigarettes	2.0	0.13	1.7

Possible differences in the composition or toxicology of the smoke delivered by these cigarettes have not been investigated.

Table ES-4. Ignition Propensities of Patented Cigarettes

Designation	No. Ignitions No. Tests	Percent
301-Control	25/25	100
301	29/50	58
302-Control	24/25	96
302	10/50	20
303-Control	24/25	100
303	32/60	53
304-Control	25/25	100
304	33/50	66
305-Control	25/25	100
305	13/60	22

tions in the paper, an additive to one location of the tobacco column, an additive throughout the tobacco column, and an additive to the exterior of the paper.

- Ignition results from the bench-scale testing correlated very well with corresponding data from experiments with chairs made with the same fabrics and padding materials.
- The physics of the ignition process is a function of both the cigarette and the substrate. Therefore, an accurate ignition propensity measurement apparatus must involve the two components.
- Intrusive probes of the ignition process (e.g., thermocouples, heat flux gauges) perturb the delicately balanced system. The induced errors can be estimated if the probes are small and well-selected. With care, (non-intrusive) infrared imaging can be used to study the thermal profiles on non-igniting or igniting substrates.
- An approximate correlation exists between the cigarette coal area and ignition propensity. Peak coal surface temperatures (and thus peak heat fluxes) did not vary sufficiently to demonstrate a correlation with ignition tendency for the cigarettes tested.
- Oxygen depletion in the vicinity of the ignition site is important during the ignition process, but is sufficiently similar for all cigarettes examined so as not to account for their relative ignition propensities.
- It is possible to construct a complex computer model of the smoldering combustion of a cigarette and the response of an idealized substrate. With all its simplifications, this preliminary model is sufficiently realistic to (1) manifest the most important and most sensitive physical features of the ignition process and (2) reproduce some of the cigarette characteristics that do and do not affect ignition propensity. Thus, the model could potentially be used to screen possible combinations of (included) charac-

Table ES-5. Comparison of Ignition Propensities of Tested Cigarettes at Full- and Reduced-Scales

Cigarette Number	Percent Ignitions	
	Bench-Scale	Full-Scale
6	74	73
129	13	23
106	3	6
114	6	14
201	0	6

teristics that offer increased fire safety. At present, however, the code for this preliminary model is very slow and not user-friendly.

- The current, mini-mockup methods are valid for research measurements of the ignition propensity of cigarettes. However, their use in a *standard* test method of cigarette performance is compromised by the variability in the commercial fabrics and paddings used in the mockup.
- Several alternative candidate test methods for measuring the cigarette ignition propensity of soft furnishings were evaluated; none was usable in its current state of development. Two promising approaches to cigarette testing are proposed. The first modifies the existing mockup procedure using specially-prepared, well-controlled fabrics and paddings. The second uses a non-reactive substrate at variable temperature to determine the minimum needed cigarette heat-loss rate for extinguishment. All need further development before promulgation.

Priority Further Research Directions

In any closed-end research effort such as this one, there are many ideas that cannot be pursued and others that evolve during the project. The following is a tabulation of those studies whose results are important to a sound understanding of the cigarette/furniture ignition phenomenon and to realization of the research into practical usage.

- Both cigarette manufacturers and the public need a test to determine how less ignition-prone cigarettes perform. The test should be relatable to the real-world situation and should be simple enough to be used as part of a quality

assurance program. Three promising approaches for distinguishing between high, moderate, and low ignition propensity cigarettes are:

- Testing with non-smoldering (inert) substrates, e.g., extinguishment of cigarettes on a glass plate or a porous frit, heated to adjusted, controlled temperatures.
- Testing with alternative reactive (smoldering) substrates, such as with controlled addition of selected amounts of smolder-enhancing ions to multiple layers of α -cellulose paper.
- Testing with controlled reactive fabric/padding substrates; mockup testing using "standardized" substrates created by the addition of selected amounts of smolder-enhancing ions.
- The current research has indicated positive directions for reducing cigarette ignition propensity. Research is needed on more combinations of these factors, especially lower tobacco content and modified paper permeability and thickness. Variations selected with the computer model should also be studied.
- Performance data for current market cigarettes should be generated by use of a new test method. These data could then be compared to future year cigarette performance.
- For a wider range of cigarettes and substrates, extensive research is needed to better measure and define the effect of the substrate on cigarette ignition propensity, the ignition kinetics, and the components of heat transfer (radiation, convection, conduction).
- More measurements are needed of the cigarette ignition physics in crevice configurations.
- The preliminary computer model of the smoldering cigarette, while operational, would benefit from key upgrades: multi-step tobacco pyrolysis and combustion, including changes resulting from paper modification; inclusion of free and combustion-generated water; more realistic movement of air and combustion gases within the cigarette; and detailed paper behavior (changes in permeability and combustibility) as a function of temperature.
- Similarly, the substrate model should be amended to include: two-layer (fabric plus padding) construction, heat-induced reactivity, and crevice geometry capability.
- The computer models should be made more time-efficient for efficient parametric variation of cigarette and substrate variables.

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APPENDIX C

**"Overview: Practicability of Developing a Performance Standard to
Reduce Cigarette Ignition Propensity"**

OVERVIEW

**Practicability of Developing a Performance Standard
to Reduce Cigarette Ignition Propensity**

1

U.S. CONSUMER PRODUCT SAFETY

COMMISSION

JACQUELINE JONES-SMITH, CHAIRMAN

AUGUST 1993



Fire Safe Cigarette Act of 1990

Under the Cigarette Safety Act of 1984 (P.L. 98-567), the Technical Study Group on Cigarette and Little Cigar Fire Safety (TSG) found that it is technically feasible and may be commercially feasible to develop a cigarette that will have a significantly reduced propensity to ignite furniture and mattresses. Furthermore, they found that the overall impact of such a cigarette on other aspects of the United States society and economy may be minimal.

Recognizing that cigarette-ignited fires continue to be the leading cause of fire deaths in the United States, the Fire Safe Cigarette Act of 1990 (P.L. 101-352) was passed by the 101st Congress and signed into law on August 10, 1990. The Act deemed it appropriate for the U.S. Consumer Product Safety Commission to complete the research recommended by the TSG and provide, by August 10, 1993, an assessment of the practicality of a cigarette fire safety performance standard.

Three particular tasks were assigned to the National Institute of Standards and Technology's Building and Fire Research Laboratory:

- develop a standard test method to determine cigarette ignition propensity,
- compile performance data for cigarettes using the standard test method, and
- conduct laboratory studies on and computer modeling of ignition physics to develop valid, user-friendly predictive capability.

Three tasks were assigned to the Consumer Product Safety Commission:

- design and implement a study to collect baseline and follow-up data about the characteristics of cigarettes, products ignited, and smokers involved in fires,
- develop information on societal costs of cigarette-ignited fires, and
- in consultation with the Secretary of Health and Human Services, develop information on changes in the toxicity of smoke and resultant health effects from cigarette prototypes.

The Act also established a Technical Advisory Group to advise and work with the two agencies.

This report is one of six describing the research performed and the results obtained. Copies of these reports may be obtained from the **U.S. Consumer Product Safety Commission, Washington, DC 20207.**

1

OVERVIEW

Practicability of Developing a Performance Standard to Reduce Cigarette Ignition Propensity

U.S. Consumer Product Safety Commission

Jacqueline Jones-Smith, Chairman

Beatrice Harwood, Project Manager

August 1993



Volume 1. Overview

Table of Contents

Acknowledgements	iii
I. Executive Summary	vii
II. Introduction	1
III. Summary of Research	
A. Test Method Development	3
B. Testing of Commercial Cigarettes.....	7
C. Ignition Physics/Computer Modeling	9
D. Fire Incident Study	11
E. Toxicity Testing Plan	15
F. Societal Cost of Cigarette Fires	19
IV. Technical Advisory Group	23
V. Practicability of Developing a Performance Standard	25
Appendix A: Advisory Opinion of Technical Advisory Group	A1
Appendix B: Copy of Fire Safe Cigarette Act of 1990.....	B1

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

The Chairman

August 9, 1993

*The Honorable Albert Gore
President of the Senate
Washington, D.C. 20510*

Dear Mr. President:

In accordance with the provisions of the Fire Safe Cigarette Act of 1990 (Public Law 101-352), I am transmitting to the Congress the final report describing the research prescribed by the Act. The Commission and the National Institute of Standards and Technology have completed all of their assigned tasks. The findings are described in detail in the report transmitted with this letter.

While the Commission concludes that it is practicable to develop a performance standard to reduce cigarette ignition propensity, the effort to achieve such an objective is beyond both the jurisdiction and the technical capability of the agency. It would therefore be prudent for Congress, if it determines that pursuing this objective is in the national interest, to identify and delegate to a more appropriate agency the task of working with industry to develop a performance standard to reduce cigarette ignition propensity.

Sincerely,

A handwritten signature in black ink, appearing to read 'Jacqueline Jones-Smith', with a large, sweeping flourish at the end.

Jacqueline Jones-Smith

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, D.C. 20207

The Chairman

August 9, 1993

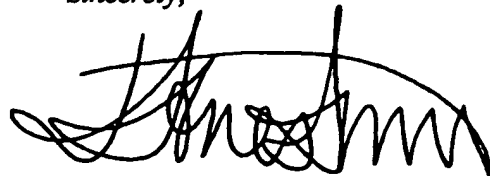
*The Honorable Thomas S. Foley
Speaker of the House
U.S. House of Representatives
Washington, D.C. 20515*

Dear Mr. Speaker:

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Jacqueline Jones-Smith

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Many persons both in and out of government made important contributions to the technical work described in this report. The Commission acknowledges their efforts.

Consumer Product Safety Commission:

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Emil Braun	J. Randall Lawson
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Richard G. Gann	Thomas J. Ohlemiller
Richard H. Harris, Jr.	Kay M. Villa
George N. Walton	

National Fire Protection Association

Rita F. Fahy	Michael J. Karter, Jr.
John R. Hall Jr.	Alison Miller

Mathematica Policy Research, Inc.

Donna Eisenhower	John Hall
Peter Forbes	

Tobacco Company Representatives/Contractors

Sarah Debanne	Leslie Lewis
Fred Clarke	Vello Norman
Ron Flack	Steve Spivack
Hugh Honeycutt	

Toxicity Consultants

David M. Burns, University of California at San Diego
C. Gary Gairola, Tobacco and Health Research Inst., Univ. of Kentucky
Jeffrey E. Harris, Internal Medicine Assoc., Mass. General Hospital
Dietrich Hoffman, American Health Foundation
Harold C. Pillsbury, Jr.

Finally, the Commission offers special thanks to the members of the **Technical Advisory Group**, who spent many hours attending meetings and reviewing the work of NIST and the Commission. Every member added to our store of knowledge:

Current Members

Ms. Jean Adams
Federal Emergency Management Agency

Mr. Charles M. Carey
American Furniture Manufacturers Association

Dr. Richard Gann
National Institute of Standards & Technology

Mr. John C. Gerard
National Fire Protection Association

Mr. James F. Hoebel
U.S. Consumer Product Safety Commission

Mr. Michael D. McGibeny
International Association of Fire Chiefs

Mr. Andrew McGuire
American Burn Association

Dr. Dallas O. Pinion
The Tobacco Institute

Dr. Edward Press
American Public Health Association

Dr. Donald Shopland
National Cancer Institute

Dr. Alexander W. Spears, III
The Tobacco Institute

Dr. David Townsend
The Tobacco Institute

Members of the Technical Advisory Group (Continued)

Dr. Jerry F. Whidby
The Tobacco Institute

Ms. Judith P. Wilkenfeld
Federal Trade Commission

Mr. James M. Williams, Sr.
Business and Institutional Furniture Manufacturers Association

Former Members

Dr. James Charles
The Tobacco Institute

Mr. Roger Lanahan
Federal Emergency Management Agency

I. Executive Summary

The Fire Safe Cigarette Act of 1990 directed the U.S. Consumer Product Safety Commission (Commission) and the National Institute of Standards and Technology (NIST) to carry out research designed to provide an assessment of the practicability of developing a performance standard to reduce cigarette ignition propensity, that is, the likelihood that a cigarette will act as an ignition source for mattresses, upholstered furniture, and similar items. This report describes the results of that research.

Practicability of Developing a Performance Standard

While the Commission concludes that it is practicable to develop a performance standard to reduce cigarette ignition propensity, it is unclear that such a standard will effectively address the number of cigarette-ignited fires. Further, the effort to achieve such an objective is beyond both the jurisdiction and the technical capability of the agency. It would, therefore, be prudent for Congress, if it determines that pursuing this objective is in the national interest, to identify and delegate to a more appropriate agency the task of working with industry to develop a performance standard to reduce cigarette ignition propensity.

To this end, broad parameters have been identified through the research specified in the Fire Safe Cigarette Act. The actual development of a standard would require the following:

- (A) setting appropriate acceptance criteria for the ignition test method;
- (B) establishing the appropriate series of tests for toxicity and setting acceptance criteria for each of those tests;
- (C) estimating the safety benefits to be derived from the imposition of such tests; and
- (D) determining the costs to cigarette manufacturers, consumers, and others of such a standard. The Commission emphasizes the importance of including toxicity tests in a standard, since even a small increase in toxicity could outweigh the beneficial effect of fewer fires.

The Fire Safe Cigarette Act directed the completion of several specific tasks, some of which were to be carried out by NIST, others by the Commission.

Research to be Completed by NIST:

Develop a Standard Test Method

This was the most important of the tasks specified by Congress: to develop a standard test method for measuring cigarette ignition propensity. NIST developed two test methods. One, the **mockup ignition test method**, measures the number of ignitions when cigarettes are placed on three types of simulated upholstery cushions with differing levels of ignition susceptibility. The second, the **cigarette extinction test method**, substitutes differing layers of filter paper for the furniture mock-ups and provides a more indirect measure of cigarette ignitability. Of these, the mock-up test is more suitable for use in a performance standard because it appears capable of providing better discrimination among cigarettes of high or moderate ignition propensity.

Test Commercial Cigarettes

NIST tested 20 selected brands of commercial cigarettes using the test methods described above. Several cigarettes performed significantly better than others on these tests, indicating that commercially marketed cigarettes differ in their probability of igniting soft furnishings, as measured by the mock-up test.

Conduct Laboratory Studies and Computer Modeling

NIST has developed a computer model of a multi-layer material (substrate) subjected to a stationary heat source with clear computer graphics and full technical documentation.

Research to be Completed by the Commission:

Implement a Fire Incident Study

The Commission conducted a study of the "characteristics of cigarettes, products ignited and smokers involved in fires." Through the services of contractors and local fire departments, it collected data on cigarette fires in eight U.S. cities and data from a companion survey of smokers in those same areas. Statistical analysis of the results indicated that, after adjusting for smoker characteristics and other cigarette specifications, the following cigarette characteristics significantly affected the risk of having a fire: filter presence and length, wrapping paper porosity, and whether the cigarette was packed in a soft pack or a box. Smoker characteristics that affected risk were gender, education, and (especially) family income.

These findings also suggest that cigarettes already in the marketplace differ in their likelihood of starting a fire.

Develop Information on the Societal Cost of Cigarette Fires

The Commission estimates that in 1990 the total direct cost of cigarette-ignited fire deaths, injuries, and property damage was approximately \$4.0 billion (in 1992 dollars). The estimated cost of fatal and non-fatal injuries, which comprises a substantial portion of the total, includes estimates for medical and transport costs, productivity loss, pain and suffering, and legal and insurance costs. Fatal injuries, estimated at 1200 in 1990, account for about \$2.5 billion of this total; hospitalized non-fatal injuries, chiefly thermal burns and smoke inhalation, account for more than \$1.0 billion. Direct property damage from cigarette fires comes to about \$500 million annually.

Develop Information on Toxicity and Health Effects (in consultation with the Secretary of Health and Human Services)

A panel of cigarette smoke toxicity experts developed a plan for testing low ignition-potential cigarettes. The purpose of the tests is to assure that whatever changes are made to achieve ignition resistance do not result in increased toxicity and adverse health effects beyond those that currently exist. Since the comprehensive set of proposed tests would cost about \$330,000 per cigarette type, a reduced number of tests estimated at \$6,900 per cigarette type was recommended as a practical first step implementation. Five cigarette types, including two prototype ignition-resistant cigarettes, two commercial brands, and a standard reference cigarette, were tested according to this reduced protocol. The results demonstrated that such an approach is practical and that the tests can distinguish differences among cigarette types.

Technical Advisory Group

The Act named a Technical Advisory Group (TAG) of 15 members representing the cigarette industry, government, the fire services, and health groups to advise the Commission and NIST on their work. The TAG met regularly during the course of this research, offering valuable comments at each stage. Several members of the TAG representing cigarette manufacturers gave or sponsored presentations of research that had been independently pursued, primarily related to the effect of air flow and fabric selection on the ignition propensity of cigarettes. The majority of the TAG supports the findings described above; a minority, almost always members representing cigarette manufacturers, disagrees, questioning primarily the validity of the test methods developed by NIST. They contend that the test methods have not sufficiently been shown to represent the way cigarettes ignite furnishings in real life. (The National Association of State Fire Marshals, although not represented on the TAG, agrees with this position.) Both majority and minority opinions are described in the TAG's final advisory report to the Commission, which appears at Appendix A.

Finally, the Commission notes that both laboratory and field studies indicate that some lower ignition propensity cigarettes already exist in the marketplace. Characteristics that have been associated with improved performance, in one or both of these studies, include lower paper porosity, smaller circumference, shorter filter, and lower tobacco density.

II. Introduction

The United States has the dubious distinction of being among the world leaders in fire death rates. On a per capita basis, about 50 percent more U.S. residents die in fires as in Europe or Japan. In 1990 the toll was almost 5,200 deaths, mostly in fires in residential structures; about 1,200 of these deaths occurred in fires started by cigarettes.

Cigarettes are not the leading cause of fires in this country, but they are by far the leading cause of fire fatalities. In spite of a significant decline during the last decade, cigarette fires accounted for 25 percent of all residential fire deaths during 1990, the most recent year for which data are available. In that year, cigarettes ignited an estimated 44,000 structural fires that caused about 1,200 deaths, 3,360 civilian injuries, and \$400 million in direct property loss.

Nine years ago Congress enacted the Cigarette Safety Act of 1984 (Pub.L. 98-567, 98 Stat. 2925). That legislation created a Technical Study Group on Cigarette and Little Cigar Safety to study the technical and commercial feasibility, economic impact, and other consequences of developing cigarettes with a minimum likelihood to ignite upholstered furniture or mattresses. The Technical Study Group consisted of 15 members appointed to represent government, industry, fire service organizations, and medical and public health groups.

Several physical characteristics of cigarettes were proposed as possibly affecting ignition potential. These characteristics were systematically examined in laboratory work performed at the National Bureau of Standards, now NIST, using prototype cigarettes specially prepared by cigarette manufacturers. The tests identified tobacco density, cigarette circumference, paper porosity, the amount of citrate, and (in separate tests) the presence of a filter as affecting the risk of ignition. Economic impact analyses and estimates of changes in fire loss from an ignition-resistant cigarette were prepared, as well as a study of the feasibility of collecting field data about cigarette-ignited fires.

In October 1987, the Technical Study Group issued its final report. The major findings were that, "it is technically feasible and may be commercially feasible to develop cigarettes with a reduced propensity to ignite upholstered furniture and mattresses." However, the group also made specific recommendations for additional research in the area of cigarette fire safety.

The Fire Safe Cigarette Act of 1990 (Pub. L. 101-352; 104 Stat. 405) responds directly to those recommendations. It directed the Commission and the National Institute of Standards and Technology (NIST) to complete the research recommended by the Technical Study Group and to assess the practicability of developing a performance standard to reduce cigarette ignition propensity. (A copy of the Act is included at Appendix B.) The following tasks were assigned:

To be Completed by the National Institute of Standards and Technology:

- o develop a standard test method to determine cigarette ignition propensity,
- o compile performance data for cigarettes using this test method, and
- o conduct laboratory studies on and computer modeling of ignition physics to develop valid, user-friendly predictive capability.

To be Completed by the Commission:

- o design and implement a study to collect baseline and follow-up data about the characteristics of cigarettes, products, and smokers involved in fires,
- o develop information on societal costs of cigarette fires, and
- o develop information on changes in the toxicity of smoke and resultant health effects from cigarette prototypes (in consultation with the Secretary of Health and Human Services, and at a cost of not more than \$50,000).

The Fire Safe Cigarette Act also established a Technical Advisory Group (TAG) to advise and assist the Commission and NIST in carrying out their work. The membership of the TAG consisted primarily of the same members who had served on the earlier Technical Study Group. The TAG met regularly throughout the course of the Act, actively participated in assessing the progress of the various tasks, and prepared a final advisory report that appears separately at Appendix A.

This is the third and final report required by the Fire Safe Cigarette Act. It describes the work undertaken to complete the tasks set forth above and assesses the practicability of developing a performance standard to reduce cigarette ignition propensity. Separate volumes provide additional details about the technical work on each task.

III. Summary of Research

A. Test Method Development

The Fire Safe Cigarette Act directed NIST to develop a standard test method to determine cigarette ignition propensity. The work was a follow-on to research described in the final report of the Technical Study Group in 1987.

In that report, NIST described several characteristics of cigarettes that were found to be related to their ignition propensity, based on tests conducted on a specially made series of experimental cigarettes. Those tests were performed using several different combinations of fabrics and upholstery filling materials (substrates) to represent and model the ignition performance of soft furnishings. The characteristics that affected the risk of ignition were tobacco density, cigarette circumference, paper porosity, presence of a filter, and, to a lesser extent, the addition of citrate to the wrapping paper.

Because the original experimental cigarettes were no longer available in sufficient quantity to complete the work, a new series of experimental cigarettes was provided by the cigarette manufacturers, intended to repeat the range of characteristics of the original. Five of the remade experimental cigarettes were selected to serve as calibration for the test method under development.

Mockup Ignition Method: The ignition of furniture or bedding by a cigarette is a highly interactive process; that is, properties of the substrate and of the cigarette play equally critical roles in determining whether or not ignition will occur. In order to develop a reliable test that could be used repeatedly over many years with the expectation that it will yield consistent results, particular care was needed to select the appropriate test materials.

A mockup consisting of a single layer of raw cotton duck fabric over polyurethane foam was selected. Cotton duck, which is commonly known as canvas, was chosen for several reasons. It is used in large quantities by the military and there are military specifications for its construction. These facts help to assure that it will be available indefinitely, and that its properties will remain consistent. Cotton duck also has ignition characteristics that allow discrimination among cigarettes *within the ignition propensity range of both the experimental cigarettes and current commercial cigarettes*. This point is crucial to the reliability and validity of the test method. Some fabrics will be ignited by all cigarettes; others will not be ignited by any cigarette. Such fabrics are of no use to discriminate among various cigarettes.

Cotton duck fabric is manufactured in several weights of varying susceptibility to ignition by a cigarette. The test procedure includes performing the test on three different weights of cotton duck (and in one case, an added layer of polyethylene film between the fabric and foam), with 48 replicates per test. The tests allow for the examination of cigarettes across a broad range of ignition propensity performance.

The ignition process is a subtle one, and it is readily affected by air movement. In actual fire situations, cigarettes may lie in various positions on and within furnishings, and air movement in the vicinity is thought to encompass a range from essentially zero upward. While actual air flows are not quantified, air flow velocities are likely to be variable, randomly oriented with respect to the cigarette, and low. For the test, NIST chose to use a slightly-modified version of the test chamber developed by the cigarette industry. This chamber is a closed plastic box that has a prominent "chimney" at the top to allow smoke to exit and an equal amount of air to flow back in. Conditions within the box are essentially still; what air movement exists is caused by the rising smoke and replacement air flow. NIST chose this condition because it is within the range of actual conditions, and it requires minimal effort to obtain a repeatable test environment.

Cigarette Extinction Test Method: NIST also investigated the feasibility of a test method that could discriminate over a wide range of cigarette ignition propensities with more easily standardized materials. The substrate materials finally selected were 3, 10, and 15 layers of standard cellulosic filter paper that effectively provide varying thermal absorption. Thus, as more layers are added, more of the heat of the cigarette is drawn away, and the more likely the cigarette is to self-extinguish. It should thus take more layers of paper to cause a more ignition-prone cigarette to self-extinguish in the test.

Interlaboratory Study: A major element of the development of both test methods was the "round robin" series of tests to demonstrate the reproducibility of the method. NIST arranged the participation of nine laboratories, including Federal and state government laboratories, cigarette industry laboratories, and a commercial testing laboratory. Each lab tested five prototype cigarettes, selected from remakes of the original set of experimental cigarettes, using both the mockup ignition method and the cigarette extinction method. The labs were provided with a written protocol for conducting the tests and all of the necessary test materials, including the experimental cigarettes.

The results of the interlaboratory tests indicate that the test methods are repeatable and reproducible within acceptable limits. While NIST believes either method is appropriate for routine use in measuring cigarette performance, the Mockup Ignition Test Method is more suitable for use in a performance standard

because it provides better discrimination among cigarettes at the higher range of ignition propensity.

The development of the two test methods constitutes the most important task under the Fire Safe Cigarette Act of 1990. Much of the discussion during the Technical Advisory Group meetings, and a significant amount of correspondence, concerned this work. Throughout the process of developing the tests, many decisions and selections had to be made. The information underlying these selections, and the bases for the decisions made, were the subject of considerable attention and controversy.

Members of the TAG representing cigarette manufacturers have introduced considerable data disputing the validity of the test conditions as representative of real life conditions, particularly with regard to fabric selection and air flow conditions. In one series of tests, a variety of upholstery fabrics purchased at retail was substituted for the cotton duck fabrics and purportedly tested according to the NIST protocol, using five experimental cigarettes of varying ignition propensity according to the 1987 NIST research. This research suggested that with some of the fabrics there was a reversal of ranking from the NIST tests; that is, cigarettes that performed well on the NIST tests had many ignitions, while cigarettes that performed badly had few ignitions. However, there was no evidence that in the aggregate the rankings were reversed.

One cigarette manufacturer also commissioned a study by the Battelle Memorial Institute of cigarette ignition tests conducted under a variety of air flow conditions. These data, introduced nearly at the end of the 3 year research period, also purported to indicate that the introduction of air flow into the test chamber, even at a rate of 0.1 ft./min., showed reversals of ranking from the results that would have been obtained from the NIST test. Although NIST is confident that its test method reasonably reflects what happens in the real world, it acknowledges that if data emerge to establish that changes are needed, the test methods could be modified.

Conclusions: NIST has developed two separate methods for measuring the propensity of cigarettes to ignite soft furnishings. The test methods are repeatable and reproducible within reasonable limits. Further, based on research conducted for the Technical Study Group during 1984 to 1987, they adequately reflect what happens in the real world when cigarettes are dropped on furnishings. The mock-up ignition method is more suitable for use in a performance standard.

A complete description of the test method development research is at Volume 2 of this report, "Test Methods for Quantifying the Propensity of Cigarettes to Ignite Soft Furnishings."

B. Testing of Commercial Cigarettes

In accordance with the directives of the Fire Safe Cigarette Act, NIST compiled performance data on a limited number of commercial cigarettes, using both test methods. The 20 cigarettes tested were selected from among more than 500 "packings" available on the commercial market at the time of testing. NIST selected 14 cigarettes that represent a significant proportion of the market in terms of sales figures, and 6 others that were expected to yield reduced ignition propensity because of their physical characteristics.

Because it was anticipated that many of the cigarette types would exhibit high ignition propensity, an abbreviated protocol was employed. This was based upon the assumption that if a cigarette displayed 100 percent ignitions on the most ignition-resistant substrate, the number of replicates could be reduced for the remaining substrates.

With one minor exception, all of the 14 best selling cigarettes ignited the test fabrics in all tests. Of the six cigarettes expected to display reduced propensity, almost all showed fewer ignitions on the hardest-to-ignite fabric, and at least one differentiated at the intermediate level. Similar results were obtained using the cigarette extinction method.

The testing of commercial cigarettes has provided a limited baseline of data for comparison purposes. In addition, it has demonstrated the high ignition propensity of commercial cigarettes in general compared to the experimental cigarettes. It has shown that some cigarettes on the market have a lower ignition propensity when tested in accordance with the test method developed by NIST. A detailed report of the test results is included in Appendix G of Volume 2.

C. Ignition Physics and Computer Modeling

The Fire Safe Cigarette Act directed NIST to conduct laboratory studies on and computer modeling of ignition physics to develop valid, user-friendly predictive capability. The plan intended at the outset has been modified somewhat by the complexity of the mathematical modeling and by the exigencies of the test method development project. However, NIST has developed computer models of a multi-layer cushion (substrate) subjected to a stationary heat source, a model of a burning cigarette lying on a substrate, and a protocol to use the two together. A description appears in Volume 3 of this report, "A Computer Model of the Smoldering Ignition of Furniture."

D. Cigarette Fire Incident Study

The Fire Safe Cigarette Act directed the Commission to collect data about the characteristics of cigarettes, smokers, and materials ignited in cigarette fires. Using two independent contractors, the Commission conducted a field study of cigarette fires and a survey of smokers in the communities where the fires occurred. The primary purpose of the study was to determine whether any physical characteristics of currently manufactured cigarettes were significantly associated with the risk of fire, after controlling for other cigarette and smoker characteristics.

Data Collection on Fire Incidents

The National Fire Protection Association was the contractor for the field study. With the cooperation of fire departments in Baltimore, MD; Cleveland, OH; Columbus, OH; Dallas, TX; Denver, CO; Houston TX; Philadelphia, PA; and Portland, OR, the contractor collected data over a 13 month period, from December 1991 through December 1992. During that time, 564 fires were reported for which the attending fire department could determine the identity of the smoker and the brand of cigarette believed to have started the fire.

Data Collection on Smokers

Mathematica Policy Research, Inc., the Commission's contractor for the comparison group of smokers, collected demographic and cigarette preference data from a sample of smokers in the same geographical areas served by the eight participating fire departments. The sample was drawn by random digit dialing from telephone exchanges within the fire department service areas. Information was collected on all smokers in a given household, as reported by one adult member of the household. After the elimination of data from households not located within the fire department service areas and from households where fires had occurred within the last year, 1,611 smokers comprised the sample that served as a comparison for the fire incident group.

Data obtained from Manufacturers

Research carried out during 1984-87 identified several physical characteristics of cigarettes that significantly affected their risk of igniting upholstery materials in laboratory tests. The characteristics included tobacco density, circumference, paper porosity, the amount of citrate additive, and the presence of a filter. Since many of these characteristics cannot be determined from physical inspection, the Commission solicited these specifications from manufacturers, who submitted the requested data about the cigarettes that they currently manufacture.

Results

The data were analyzed using a statistical procedure known as logistic regression. This is a rigorous method of analysis by which many different demographic and cigarette characteristics can be analyzed simultaneously to determine the strength of their respective associations with the risk of fire. Interactions between demographic and cigarette characteristics can also be examined.

The demographic variables included in the analysis were household income, education, gender, race, age, and city of residence. One demographic variable, the number of cigarettes smoked daily, was collected but discarded from the analysis because of coding discrepancies between the fire and smoker groups. Cigarette characteristics included in the analysis were tobacco column length, filter length, circumference, tobacco density, amount of tobacco, menthol, paper porosity, citrate additive (to the wrapping paper), and pack type (soft pack or box).

After controlling for all smoker characteristics, several cigarette characteristics were found to have a significant effect on the risk of fire: (a) the presence and length of a filter, (b) wrapping paper porosity, and (c) pack type. Specifically, a higher fire risk was observed for unfiltered cigarettes, for cigarettes with a short rather than a long filter, for cigarettes with higher paper porosity, and for cigarettes from a soft pack rather than a box. Significant interactions of household income with both education and race were found, and a significant interaction between pack type and gender. (The excess fire risk for soft pack cigarettes was only statistically significant among male smokers.)

The smoker characteristics that were found to be significant were: (a) income, (b) education, and (c) gender. Income had a more profound effect on risk than any other smoker or cigarette characteristic. Families with an income of less than \$10,000 a year were six times as likely to have a fire as families with an annual income of \$20,000 or more.

Various sensitivity tests were conducted to determine how dependent the logistic regression modeling was on certain aspects of the data. Areas of investigation included: the sensitivity of the regression modeling to the low fire reporting rate in Columbus, OH; to the use of self vs. proxy reporting (i.e., obtaining information directly from the smoker vs. from another household member); to the cluster sampling of the smoking households in the smoker survey; and to the effect of excluding cases where data on income or education were not available. The sensitivity tests indicated that the results described above were not significantly affected by any of these issues.

Discussion

Some of these epidemiological findings confirmed laboratory findings, some did not. Paper porosity was found to be significant in both laboratory and field studies. Tobacco density and cigarette circumference were significant in laboratory tests but not in the field study. It should be noted, however, that while the range of these characteristics in the field study included a few values at either end of the spectrum of characteristics examined in experimental cigarettes, most of the values for density and circumference among currently manufactured cigarettes were distributed closely around the mean. The fact that no significant differences were found may merely reflect the small sample size at either end of the range.

Results from a single epidemiological study cannot be determined to be definitive. By nature field studies are less rigorous than those conducted in a laboratory, where extraneous variables can be more rigidly controlled. The possibility cannot be ruled out that some of the characteristics shown to be significant may be surrogates for other cigarette characteristics unknown at this time. Only a few have been examined.

On the other hand, field studies have the advantage of relating directly to real life situations. The observed high risk for unfiltered cigarettes and cigarettes with a high paper-porosity has been confirmed in laboratory studies. The effect of filter length, though not suggested previously, is a logical extension of that finding.

In summary, the results suggest that cigarettes currently on the market differ significantly in their risk of starting a fire, even after controlling for smoker characteristics.

A detailed analysis of the fire incident study and the smoker survey is at Volume 4 of this report.

E. Toxicity Testing Plan

The Fire-Safe Cigarette Act directed the Commission, in consultation with the Secretary of the Department of Health and Human Services (DHHS), to develop information on changes in the toxicity of smoke and resultant health effects of cigarettes with a reduced probability of starting fires.

The reasons for considering the health implications of ignition-resistant cigarettes are compelling. There are about 50 million smokers in the U.S., of whom an estimated 434,000 die annually from adverse health effects associated with smoking. According to the Department of Health and Human Services, the societal cost of smoking in the U.S. is estimated at \$68 billion per year in direct and indirect costs. Thus, even a small increase in the risk of an adverse health effect due to new cigarette types could result in a great increase in human and economic costs. If this occurs, it could counter the benefits achieved from the reduction of fires by new cigarette types.

The Act imposed a limit of \$50,000 for evaluating health effects. Both the Commission and the TAG agreed that the spending limit precluded any significant amount of actual testing of cigarette prototypes, especially since the nature and extent of required testing had not been established. In consultation with Donald Shopland, MD, of the DHHS, and with the concurrence of the TAG, the Commission decided to convene a panel of health experts who would develop a toxicological testing plan. The experts would define the significant issues and recommend the tests necessary for a comprehensive assessment of health effects of low-ignition potential cigarette smoke.

The experts were selected from a list proposed by the TAG, the DHHS, and the Commission. Each prepared specific chapters of the final report:

~~JEFFREY E. HARRIS, MD, PhD, PROVIDED AN OVERVIEW OF THE ISSUES
RELATED TO DEVELOPMENT OF A PLAN AND THE MAJOR HEALTH EFFECTS OF
TOBACCO SMOKE.~~

HAROLD C. PILLSBURY, JR., DESCRIBED THE SMOKING MACHINE AND
PROTOCOL FOR THE COLLECTION OF GASES AND PARTICULATE MATTER FROM
CIGARETTE SMOKE.

DAVID M. BURNS, MD, DISCUSSED THE EFFECT OF SMOKING TOPOGRAPHY
(INHALATION PROFILE) AND BIOLOGICAL INDICATORS OF TOBACCO SMOKE IN
HUMANS.

DIETRICH HOFFMANN, PHD, PROPOSED TESTS FOR THE ANALYSIS OF TOXIC SMOKE CONSTITUENTS AND IN VIVO BIOASSAYS FOR CARCINOGENICITY.

GARY GAIROLA, PHD, SUGGESTED SHORT-TERM TESTS FOR THE EVALUATION OF TOXICITY.

Panel Findings

Adverse health effects that determine the nature of required toxicity tests include the following: lung and throat cancer, chronic obstructive lung disease, heart and vessel disease, male and female reproductive effects, fetal growth retardation, and psychophysiological addiction. Not all of these health effects can be addressed at this time because of the impracticality or non-existence of adequate tests, high costs, or long periods of time needed for testing.

Other major issues surrounding the testing included evaluation of sidestream smoke, analytical vs. *in vitro* vs. *in vivo* testing, machine reflection of human smoking behavior, performance vs. design-based testing, screening models, and disclosure of new additives or increased levels of existing additives.

A smoking machine protocol for measuring nicotine, carbon monoxide, and particulate matter (tar) was developed by the Federal Trade Commission. It is the only required toxicity testing for cigarettes in the U.S., and it prescribes no limits of acceptability. However, cigarette smoke contains more than 3,500 chemicals. The panel agreed that present knowledge on the adverse health effects and toxic constituents of cigarette smoke dictated further testing beyond the FTC requirements.

Since low ignition-potential cigarettes might cause changes in smoking behaviors and therefore modify the toxicity, altered human behavior may become a significant factor in exposure. Analysis of selected chemicals known to be associated with adverse health effects may not be sufficient to predict the net toxicity of the smoke. *In vitro* and *in vivo* testing are needed.

Health Effects Assessment Plan

After consideration of the testing proposed by the expert panel, and in consultation with DHHS, the Commission developed the following performance-based plan. Four sequential tiers of testing are proposed:

Tier I: chemical analyses of smoke: acidity and reduction/oxidation potential, carbon monoxide, hydrogen cyanide, and nitrogen oxides, aldehydes, volatile hydrocarbons, volatile nitrosamines, particulate matter (tar), catechols, nicotine, phenols, polynuclear aromatic hydrocarbons, and tobacco-specific nitrosamines.

Tier II: *in vitro* tests: *Salmonella* mutagenicity (Ames' assay) and mouse embryo fibroblast cell transformation assay.

Tier III: indicators of human smoking behavior: levels of cotinine and carbon monoxide in human subjects, smoker topography (puff volume, frequency, and draw velocity).

Tier IV: *in vivo* tests: mouse inflammatory lung response, hamster respiratory tract carcinogenicity, and mouse skin painting carcinogenicity.

Satisfactory performance at one tier would be required before proceeding to the next. The toxicities of the prototypes should be compared with marketed types intended for replacement or comparable marketed types, and standard reference cigarettes. However, the definition of acceptable levels of performance at any tier is beyond the scope of this plan. Moreover, it is beyond the direction given by the Act.

The FTC method is the basis for the mechanical generation of smoke constituents for the tests described in Tier I. However, the test protocol, especially in terms of puff volume, frequency, and draw velocity, may need to be revised based on actual smoking behavior as measured in Tier III. Unless consistent correlation of testing results of mainstream and sidestream smokes can be shown, both must be separately collected and tested.

Additives in the prototypes exceeding the current levels of use or new additives must be disclosed to determine whether additional testing is needed. Improvements in toxicity testing and risk evaluation may occur in the future and should be considered during possible revisions of the plan.

First implementation step

Completion of all four testing tiers is costly relative to the present level of testing required by FTC (\$330,000 in direct costs for Tiers I, II, and IV). Therefore, a stepwise implementation of the plan is suggested.

A practical subset of recommended tests should comprise, as a minimum, limited testing from Tiers I and II. (Subsequent steps should consider the more comprehensive recommended test plan.) The estimated direct cost of this first step was \$6,900 per cigarette type tested, although the Commission was able to contract for the work for somewhat less. The tests included: from Tier I, tests for nicotine, tar (FTC), carbon monoxide, whole smoke pH, benzo(a)pyrene, and tobacco-specific nitrosamines; from Tier II, the Salmonella mutagenicity ("Ames") assay. Smoke and condensate were generated by machine according to the FTC protocol.

The Commission contracted with two laboratories to conduct this limited test protocol on five cigarettes-- two commercial brands, two low ignition-potential prototypes, and a standard reference cigarette. The results indicate that the plan will provide data that can distinguish differences in toxicities among cigarette types. The demonstration also shows that the cost estimates are reasonable and the implementation of limited tests from Tiers I and II is feasible.

A complete review of the toxicity findings is at Volume 5, Toxicity Testing Plan.

F. Societal Cost of Cigarette Fires

Introduction

The Fire Safe Cigarette Act directed the Commission to "develop information on the societal costs of cigarette-ignited fires." Volume 6 of this report presents a summary of the latest available data on the estimated economic costs of deaths, injuries and property damage resulting from structural fires started with smoking materials. These are the costs most likely to be significantly affected by action to reduce the ignition propensity of commercial cigarettes. The estimates do not include other costs to the public associated with fires and fire safety but less directly related to cigarette-ignited fires.

A substantial amount of new information regarding the cost of injuries was accumulated for this task. Greatly improved estimates of costs associated with fatal and non-fatal burn, anoxia and other injuries were developed, including estimated medical costs, transport costs, productivity losses, pain and suffering, and legal and health insurance administrative costs. The estimates, presented in summary below, are reasonably applicable to injuries resulting from cigarette-ignited fires. Estimates for the numbers of fatalities and non-fatal injuries and for property damage are from CPSC's Directorate for Epidemiology, the U.S. Fire Administration, and the National Fire Protection Association.

Estimated Societal Costs

During 1990 the total cost of cigarette-ignited fire deaths, injuries and property damage was estimated at approximately \$4.0 billion (in 1992 dollars, excluding costs associated with public expenditures on fire protection, firefighting services, and other costs less directly associated with or affected by cigarette-ignited fires). This comprises over 1,200 deaths and nearly 7,000 treated civilian and firefighter injuries in residential and non-residential smoking fires (99 percent of total-estimated-injury-costs---and-virtually all deaths -- involve civilian casualties) as well as nearly \$0.5 billion in property damage. Fatal injuries account for about \$2.5 billion (60 percent) of this total; hospitalized, non-fatal injuries -- chiefly thermal burns and anoxia -- account for over \$1.0 billion. Estimated total annual costs for all injuries are shown in Table 1; detailed cost components on a per-case average basis are estimated in Table 2.

Table 1
Societal Costs of Cigarette-Ignited Fire-related Injuries
(\$ million, 1992 dollars)

<u>Cost Component</u>	<u>Estimated Cost</u>	<u>Percent</u>
Medical	76	2.1
Transport	1	<0.1
Productivity Loss	705	19.7
Pain & Suffering	2,763	77.1
Legal	35	1.0
Insurance/Admin	5	0.1
TOTAL	\$ 3,585	100.0

Source: Miller, et al, National Public Services Research Institute

Detailed breakdowns of injury cost components on a per-case average basis are estimated for burns and anoxia (the major injury categories) in Table 2.

Table 2
Estimated Average Per-case Cost Components
for Cigarette-Ignited Burn and Anoxia Injuries
(1992 dollars)

	<u>Burns</u>			<u>Anoxia</u>		
	<u>Hospitalized</u>		ER	<u>Hospitalized</u>		ER
	Fatal	Non-Fatal	Only	Fatal	Non-Fatal	Only
Medical	11,199	50,963	698	10,860	4,434	617
Transport	453	211	26	416	253	111
Productivity	530,000	34,000	2,750	530,000	11,000	2,750
Pain & Suff.	1,470,000	785,000	10,700	1,470,000	105,000	9,500
Legal	19,000	8,500	0	19,000	1,500	0
Ins./Admin.	816	3,582	51	789	328	51
TOTAL	2,000,000	875,000	14,000	2,000,000	125,000	13,000

Source: NPSRI. Estimates are based on breakdowns for civilian injuries

Medical costs were derived from an exhaustive review of data from a variety of medical data bases, with detailed corroboration and cross-checking. Estimates for productivity losses, litigation costs, and emergency transport are drawn from existing and newly-generated data. Pain and suffering estimates, which comprise a substantial proportion of total costs, are largely based on a thorough analysis of jury verdicts in fire injury cases. Each of the cost components is based on averages of observed ranges and represents a conservative approach to estimating costs.

Conference on Fire-related Injuries

A national conference of leading burn care experts was held to discuss trends in treatments, costs and outcomes of fire-related injuries. The conferees noted the substantial reduction in the mortality rates for hospitalized burn patients over the past two decades led to an increase in the proportion of resources devoted to extremely severe burn cases. This emphasis on badly burned victims may tend to increase total costs, especially since treatments being developed for the most severe burn and anoxia cases are likely to be very expensive. Thus, costs can be expected to continue to be very high for fire-related injuries. On the other hand, functional and cosmetic outcomes for less severe burns have improved dramatically in recent years, and increasing outpatient management of burn injuries in lieu of hospitalization may tend to curb potential cost increases.

Potential Benefits of Lower Ignition Propensity Cigarettes

The Act does not call for an analysis of the benefits - or costs - of any specific set of performance or other requirements for cigarette fire safety. The 1987 TSG final report contained analyses of potential benefits and costs associated with a variety of possible cigarette modifications, but no specific test method or performance requirements were presented or analyzed. The range of potential benefits would depend on the nature, technical and commercial feasibility, and projected effectiveness of any possible requirements. The available data suggest, however, that substantial fire safety benefits could accompany reductions in the ignition propensity of commercial cigarettes. While some currently-marketed commercial cigarettes may have lower ignition propensity, uncertainty about the commercial feasibility of lower ignition propensity cigarettes remains. Similarly, the potential net benefits (i.e., net of economic costs) are unknown, and may be especially sensitive to any possible health effects of altering the chemical composition of cigarette smoke.

Although the societal cost estimates may be conservative, not all smoking fires are addressable by widespread use of lower ignition propensity cigarettes. Therefore, the cost estimates may overstate the likely level of benefits of mandatory or other action to reduce cigarette ignition propensity. Any future analysis of the economic efficiency of lower ignition propensity cigarettes would, however, involve estimating the likely benefits (and costs) to the public of a reasoned set of alternatives aimed at improved cigarette fire safety.

IV. Technical Advisory Group

The Fire Safe Cigarette Act established a Technical Advisory Group (TAG) to advise and work with the Consumer Product Safety Commission and NIST on the implementation of the Act. The members were, in general, the same individuals who served on the Technical Study Group (TSG) for the Cigarette Safety Act of 1984.

The Technical Advisory Group met regularly and discussed every aspect of the work in progress. Both NIST and Commission staff made regular presentations about the progress of the work. In addition, several members of the TAG representing cigarette manufacturers or their designated representatives presented the results of research independently undertaken. Most of the industry presentations were intended to raise doubts about the validity of the NIST test method. In addition to the questions about air flow and fabric selection, which have been discussed earlier in this report, the presentations were intended to contradict some of the statistical conclusions from the earlier report of the Technical Study Group in 1987.

The TAG issued a final advisory opinion about the research pursued under the Act and an assessment of the practicability of developing a performance standard. The majority of the TAG supported the research findings. A minority, almost always members representing the cigarette manufacturers, disagreed, questioning primarily the adequacy of the test method developed by NIST. In support of their opinion, the manufacturers introduced a large volume of oral and written testimony. The TAG's final advisory opinion includes a summary of both majority and minority positions; they appear at Appendix A of this report.

V. Practicability of Developing a Performance Standard

The research described above is relevant to the final and most critical of the directives of the Fire Safe Cigarette Act - an assessment of the practicability of developing a performance standard to address cigarette ignition propensity. There are at least five aspects to such an assessment:

1. development of an acceptable test method
2. appropriate acceptance criteria for such a test
3. possible adverse health effects
4. economic feasibility
5. cost/benefit determinations

A discussion of each of these aspects follows.

1. Development of an acceptable test method

The first requirement for a performance standard is the development of a valid and reliable test method for measuring cigarette ignition performance. (A valid test is one that measures what it is intended to measure, in this case the likelihood that a cigarette will start a fire under real life conditions. A reliable test is one that produces similar results when repeated by operators at the same or other laboratories, assuming reasonable diligence in following the test protocol.) NIST's test method research was the single most important task specified in the Act.

The Commission shares NIST's and the TAG's conclusion that the research during the present study, together with research undertaken from 1984 to 1987, establishes the validity and reliability of their test methods within reasonable limits.

Members of the TAG who represent cigarette manufacturers, as well as representatives of the National Association of State Fire Marshals, claim that the test methods developed by NIST are inadequate. Their primary contention is that the test method developed by NIST is not sufficiently related to real life conditions, particularly in terms of the test fabrics and air flow conditions in the test chamber. They have introduced considerable testimony to this effect at TAG meetings and have submitted a large quantity of written materials.

Representatives of cigarette manufacturers have introduced data indicating that under some air flow conditions and with some fabrics, there is a reversal of ignition propensity ranking from the NIST tests; that is, cigarettes that showed few ignitions using the fabrics and air flow conditions specified in the NIST test method showed many ignitions when tested on certain other fabrics or under certain other

air flow conditions, while the reverse was true for cigarettes with a demonstrated high ignition potential in the NIST test. In other words, a reversal of the expected rankings was observed.

Some of the data presented by industry (e.g., a report about air flow prepared by the Battelle Memorial Institute and data from testing fabrics commonly used in upholstered furniture) was introduced at too late a date to be thoroughly considered for this report. While NIST is confident that its test method reasonably reflects what happens in the real world, it acknowledges that if data emerge to establish that changes are needed, the test methods could be modified.

The Commission also notes that it is not necessary for the test method to discriminate adequately among low and high ignition propensity cigarettes on all fabrics and under all air flow conditions. It is only necessary that it do so in the aggregate. Few test methods or remedial strategies are effective under all possible circumstances.

The accurate and reproducible representation of a real-life process involving fire in a controlled laboratory environment is never easy because of the large number of variables involved. It is not possible in one test, or even a limited series of tests, to reproduce all real life conditions under which a cigarette may start a fire. Insofar as possible, a test must narrow the range of variables to allow examination of the performance characteristic of interest.

It is not unusual for standardized tests to employ materials and test conditions that do not exist or rarely exist in real life. The need to simulate real life must be balanced against the need to use standardized materials that will provide reliable results. If the materials and conditions chosen for a test adequately serve as surrogates for the variety of substrates and conditions found in real life, then their use is acceptable. In this case, prior research under the TSG established the ignition performance of experimental cigarettes using several different fabric and cushion combinations. Experimental cigarettes with those same characteristics were used in developing the present test method.

Cigarette manufacturers have implicitly approved the use of surrogates in their research. Repeatedly they have used fabrics treated with different levels of smolder promoters such as sodium or potassium ions as a surrogate for fabrics with varying levels of ignitability. The fabric selected by NIST, an as-received, undyed cotton duck, was chosen because of the stability of its specifications and performance over time. The three weights used represent varying levels of ignitability and provide flexibility in setting acceptance criteria.

The choice of air flow conditions presents a similar problem. It is not practical to represent all air flow conditions, and strict control of managed air flow can be difficult. The actual location and position of fire-causing cigarettes is not fully known, but epidemiological evidence suggests that the most typical furniture location is within a crevice formed by cushions. Air flow rates and air availability under such conditions are probably random, variable, and typically low. The negligible air flow rate used in the NIST tests seems fair and reasonable, and has not been persuasively refuted by industry research.

2. Acceptance Criteria

In order to translate a test method into a performance standard, one must set an appropriate acceptance (pass/fail) criterion or criteria. How many ignitions, if any, are acceptable for a prescribed number of tests? The ideal level of acceptability is one that achieves the maximum benefits in safety at the least cost, and allows for the known variability in flammability test results.

The Fire Safe Cigarette Act did not direct the Commission or NIST to establish an appropriate acceptance criterion. However, the Commission has no reason to believe that an appropriate acceptance level could not be established for the present test. Some additional lab work might be required to establish the optimal cut-off point for the number of ignitions allowed.

NIST's tests were conducted on three different weights of cotton duck, representing differing levels of ignitability, with 48 replicates per fabric. The results for the cigarettes tested suggest that acceptable differentiation might be achieved using only two of these cotton duck fabrics, and possibly fewer replicates. Test results for specific cigarettes on specific fabrics tended to be dichotomous - no or few ignitions as opposed to all or nearly all ignitions, a finding that might facilitate setting an appropriate acceptance criterion.

3. Health Effects

In addition to being a major cause of fire deaths, cigarettes are the single, major cause of premature mortality in the United States, directly responsible for an estimated 400,000 to 500,000 deaths annually. It is therefore essential to ensure that changes in the physical properties of cigarettes for the purpose of achieving reduced ignition potential do not result in additional adverse health effects. Even a small increase in human toxicity could outweigh the beneficial effects of fewer fires.

The \$50,000 spending limit to develop information on the toxicity of ignition-resistant cigarettes precluded any significant amount of testing. Instead, a panel of health experts drew up a plan for such an assessment, including both a

comprehensive four-tiered sequential series of tests and a more practical first-step alternative. A limited number of cigarettes were tested using the first step alternative series.

The Commission finds that the panel of health experts established the framework for a reasonable evaluation of the toxicity of low ignition potential cigarettes. Candidate prototypes could be compared with the brand they would replace in the marketplace or with a standard reference cigarette. However, additional technical work is necessary to establish the most reasonable series of tests and to set appropriate acceptance criteria.

The importance of pairing a performance test for cigarette ignitability with a corresponding assurance of no increased adverse health effects requires emphasis. Toxicity testing is a necessary component of the development of a performance standard for a reduced ignition potential cigarette. This aspect of developing a performance standard will require more work than any other. Although cigarette manufacturers face no current restrictions on the manufacture of cigarettes sold to the public, if modifications to current cigarettes were required to make them less likely to start fires, there would be an equal obligation to ensure that no increased adverse health effects result.

4. Commercial Feasibility

Economic research pursued under the Cigarette Safety Act of 1984 established the technical feasibility of modifying cigarettes to increase ignition resistance. Some of the changes were estimated to be achievable with only small changes in the cost of producing cigarettes. The research did not examine the acceptability of such cigarettes to smokers.

The current Act required no additional work on commercial feasibility, and the legislative history makes it plain that none was intended. At meetings of the TAG, several manufacturers have described several smoker acceptability tests that they conducted using prototype ignition-resistant cigarettes. The results indicated a low degree of smoker acceptability.

However, both the fire incident study and the NIST tests of commercial cigarettes provide evidence that some cigarettes with a reduced ignition potential are already in the marketplace. A degree of consumer acceptability has therefore already been established.

5. Cost/Benefit

The Commission has made no estimates of the cost to the public of a performance standard to reduce cigarette ignitability. The maximum benefits,

however, can be derived from estimates of the current societal cost of cigarette fires as described above. It is unlikely that any performance standard will prevent all cigarette fires. The estimated level of effectiveness would depend on factors such as the stringency of the test (where the acceptance criteria are set) and its precision in accurately predicting ignitability on the range of materials found in U.S. homes.

Although the Commission concludes that the test method developed by NIST bears a reasonable relationship with real life conditions, it notes that additional tests of the kind carried out by industry would be necessary to make the cost/benefit findings that might be required to promulgate a standard.

Summary of Practicability

In summary, the Commission concludes that it is practicable to develop a standard to reduce cigarette ignition propensity. However, the Commission notes that, in order to more fully address issues raised by other interests, additional work is needed. The Commission also concludes that such an effort is beyond both the jurisdiction and the technical capability of the agency. Therefore, the Commission respectfully suggests that should it be determined that pursuing the development of this standard is in the national interest, the Congress should identify and delegate to a more appropriate agency the task of working with industry to develop the desired performance standard.



NIST

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

July 8, 1993

The Honorable Jacqueline Jones-Smith
Chairman
Consumer Product Safety Commission
Washington, DC 20207

Dear Chairman Jones-Smith:

I am pleased to provide you with the Technical Advisory Group's (TAG) final appraisal of the tasks being carried out under the Fire-Safe Cigarette Act of 1990 (P.L. 101-352). After summarizing our activities, we present our views on the six tasks being performed by the Consumer Product Safety Commission (CPSC) and the National Institute of Standards and Technology (NIST) and our assessment of the practicability of developing a performance standard to reduce cigarette ignition propensity (IP). This letter is timed to provide input to your August 10, 1993 final report to the Congress, and most of our comments are based on interim versions of the task products. Nonetheless, we feel our assessment is valid and germane to your needs.

The chronology of our activity under the Act is as follows. Public Law 101-352 was enacted on August 10, 1990. The initial appropriation was received by CPSC on November 29, and the first funding was transferred to NIST on December 17. You appointed the TAG members by December 26. As under the Cigarette Safety Act of 1984, the membership represent:

- Federal agencies (5 members),
- cigarette manufacturing (4 members),
- public health organizations (2 members),
- fire safety organizations (2 members), and
- furniture manufacturing (2 members).

Eleven TAG meetings have been held on February 1, 1991, March 21, 1991, June 3, 1991, October 31, 1991, January 24, 1992, April 16, 1992, June 15, 1992, September 1, 1992, January 28-29, 1993, April 29-30, 1993, and June 11, 1993. A notice of each meeting was published in the Federal Register. The public audience at the meetings has been almost exclusively by technical and legal staff of the member organizations. We repeat our appreciation for the support of CPSC project staff in organizing the TAG meetings and distributing the materials needed to perform our functions.

The meetings have focused on reviews of project directions and results, both of work performed directly under the Act and also under the sponsorship of the tobacco industry. Discussion of technical and programmatic issues has been vigorous. The TAG membership is sharply divided in many facets of its assessment of the work performed under the Act. In general, where there are two

disparate views reflected in this report, the four cigarette industry representatives comprise the minority.

I. APPRAISAL OF TASKS UNDER "COMPLETION OF FIRE SAFETY RESEARCH"

With one month remaining in the lifetime of the Act, the TAG is confident that CPSC and NIST staff will complete all six of the mandated tasks. Eleven of the members of the TAG find that the work performed under the Fire Safe Cigarette Act of 1990 meets both the specific directives of the Act and responds to the overall intent. The four cigarette industry representatives, supported by industry-supported or -generated data and analyses, have expressed strong criticism of the quality and suitability of many of those products. Their assertions have generally been found non-persuasive by the other eleven members. Specific manifestations of both these positions appear under the discussion of the individual tasks.

A. NIST Tasks:

1. Develop a standard test method to determine cigarette ignition propensity. The TAG feels that this is the most important of the tasks and, as such, it has received the most attention. The TAG members have reviewed near-final documentation of the test method development.

Conducting new research and building on research performed under the direction of the Technical Study Group (TSG) under the Cigarette Safety Act of 1984 and related work performed by the cigarette industry, NIST has developed two test methods:

- The *Mock-up Ignition Test Method* uses three types of simulated upholstery cushions, each with a different cigarette ignition susceptibility. Each assembly (substrate) consists of a top layer of one of three weights of cotton duck fabric; a cushion of a polyurethane foam; and, in the least susceptible substrate, a thin layer of thermoplastic film in between. The performance measure is whether or not the mock-up is ignited by the cigarette placed on it.
- The *Cigarette Extinction Test Method* replaces the more complex substrate with 3, 10, or 15 layers of standard cellulosic filter paper. The performance measure is whether the cigarette extinguishes before burning its full length, i.e., whether the substrate absorbs enough heat from the cigarette coal to extinguish the cigarette.

Eleven members of the TAG have accepted the two methods and commend them as successful completion of this task, believing that both methods have valid links (comparable to many current fire test methods) to real-world fire scenarios of concern. NIST has incorporated most of the relevant physics and chemistry of such ignitions, while replicating the real-world hazard to sufficient, but differing extents. Both tests offer the use of a graded measure of performance, where a range of acceptable levels can be set by the regulator, although neither NIST nor the TAG have addressed specific regulatory criteria. Ignition propensity measurements using the two tests are consistent with each other and with other IP data. These TAG members also accept the provided basis for using only flat substrates, conducting all testing without externally-imposed air flow, and use of the selected substrate materials. The test materials are deemed likely to be available, with long-term consistency, in the foreseeable future. In general, the eleven are not persuaded by the cigarette industry representatives' assertions that the test methods are inaccurate or inappropriate.

The eleven members also find that the nine-laboratory study showed that the two methods are of useful reproducibility. The lab-to-lab variation in the proportion of ignitions is comparable to other fire test methods currently being used to regulate materials which may be involved in unwanted fires.

By contrast, the four cigarette industry members are sharply critical of the NIST research and the resulting methods. They assert the report contains conjecture on selections and assumptions made in developing the proposed test method. They further make the following assertions. Many of the explanations are contrary to research results at NIST and elsewhere. The proposed method employs substrates rarely, if ever, used in upholstered furniture or mattresses. One of the criteria used by NIST to select the cotton duck fabrics was that they would show large fractions of ignitions by popular commercial cigarettes; similar criteria were used in the design of the Extinction Method as well. The fabrics' chemical and physical properties are not representative of furniture or mattresses. They show inverse relationships between ignitions and fabric weight compared to commonly-used commercial fabrics. Extensive cigarette industry research data indicate an interaction between substrate and cigarette characteristics resulting in the conclusion that cigarette ignition propensity rankings are substrate dependent. The proposed tests were subjected to interlaboratory studies that made use of a limited, non-random selection of experimental cigarettes. Studies by NIST and other laboratories with the duck fabrics also indicate that the crevice configuration, which was excluded from the proposed NIST test method and is of concern in real-world fire settings, produces results that are inconsistent with commercial fabrics, e.g., the crevice configuration is a less severe test than the flat configuration with the duck fabrics. With little consideration of commercial substrate characteristics, or data that relates the test method substrate to real-world substrates, the proposed test method has no obvious real-world connectivity. Effects of real-world environmental air flow on cigarettes were not investigated, even though cigarette industry data indicate that it can reverse the apparent ignition propensities of cigarettes. Similar effects which have not been investigated by NIST may result from humidity changes. During the NIST studies, certain cigarette characteristics were found to correlate with reduced ignition propensity. Little correlation was found between these characteristics and those found in the CPSC field study of cigarette fires (Task 4), further indicating the lack of a real-world relationship between the proposed test method and fires. Finally, they assert that other issues not adequately addressed or resolved by NIST include unacceptable short- and long-term reproducibility of the test method.

2. Compile performance data for (commercial) cigarettes using the standard test method. NIST has completed the testing of 20 commercial cigarettes. Fourteen of these are the best selling packings, comprising nearly 40% of total sales. The test results show that these consistently ignite the most difficult-to-ignite substrate in the Mock-up Ignition Test and burn their full length in the Cigarette Extinction Test Method. The remaining six packings tested have one or more physical properties suggesting their being less ignition prone. All of these packings showed reduced ignition propensity in the Mock-Up Ignition Test Method. Four of these packings rarely ignited the most difficult-to-ignite substrate; the other two ignited it in 40-70% of the tests. Three of the four packings showed reduced IP on the middle substrate as well. While the Cigarette Extinction Test Method is less sensitive to changes in IP, three of the packings showed markedly fewer full-length burns. All these differentiations are outside the variability of the test methods. In the combined test results of commercial and experimental cigarettes using both methods, there is one inconsistency in the results of testing of one commercial cigarette on one substrate using the Mock-Up Ignition Method.

The TAG thus observes that there are multiple brands of commercial cigarettes currently being sold that are of reduced ignition propensity, as measured by the NIST test methods.

3. Conduct laboratory studies on and computer modeling of ignition physics to develop valid, "user-friendly" predictive capability. In September, 1992, NIST published a personal-computer-based model of a multi-layer substrate subjected to a stationary heat source with computer graphics and full technical documentation. The model, an upgrade of the version developed under the prior Act, shows promise in replicating limited experimental data on ignition by a stationary heat source. The intent is to use the model in conjunction with a model of a burning cigarette (to be completed in June, 1993) to simulate the cigarette ignition process. The TAG acknowledges the first report as completion of this part of the task. The TAG has not yet received the final report containing the cigarette burning model and the protocol for using the two models together.

Two of the cigarette companies have recently requested copies of the software. In a preliminary review, one has noted that the program executes in a relatively short time, has improved numerics compared to the original version, and is easier to use if all the input parameters are known. However, the model is limited in use because of the absence of the partner cigarette burning model and poor handling of oxygen diffusion. Use of the model would be promoted by having a catalogue of the thermal and kinetic properties required by the model for different fabrics and foams.

NIST has performed several examinations of aspects of the physics of the ignition process in developing both the test methods and the computer models. These have been tightly related to the development of the test methods and the computer models. They include: chemical kinetic profiles (via thermogravimetry) of fabric decomposition in air, analysis of cigarette-to-substrate heat transfer, analysis of oxygen transport to the ignition site, development of a small heat source to simulate the energy flux from the cigarette coal, generation of ignition delay time and ignition temperature data (as functions of the oxygen level, weight of substrate fabric, padding, and applied heat flux) for model verification, and measurement of ignition environment by infrared thermography.

B. CPSC TASKS:

4. Design and implement a study to collect baseline and follow-up data about the characteristics of cigarettes, products ignited, and smokers involved in fires. The aim of this study was to examine whether any physical characteristics of currently-manufactured cigarettes affected the risk of fire, after controlling for all other known smoker and cigarette characteristics. Working with the fire departments in eight cities, the National Fire Protection Association (NFPA), under contract to CPSC, has obtained data on 564 smokers (and their cigarettes) involved in fires. A second contractor, Mathematica, obtained telephone data about 1611 smokers who did not have fires. The TAG has reviewed a draft report from NFPA.

Using a logistic regression model, and after controlling for all other variables, four cigarette characteristics were found to have a statistically significant effect on the risk of a fire: the presence and length of a filter, paper porosity, and pack type (soft pack or box). The last was more pronounced among men than among women. Education level, gender, and especially income level were significant smoker characteristics.

The systematic, wide variation of certain composition factors (e.g., tobacco density, circumference, paper porosity, and citrate in the paper) of the experimental cigarettes in the TSG research enabled analysis of their impact on ignition propensity. Commercial cigarettes do not necessarily lend themselves to similar analysis. For instance, most of the commercial cigarettes in this study were in

a narrow range of tobacco density, which was a pronounced factor identified in the TSG research. In addition, the cigarette industry uses additives other than citrates to the paper. It is thus noteworthy that two factors were identified as affecting ignition propensity in both this and the TSG studies: presence of a filter and paper porosity.

Eleven members of the TAG find that this study shows that cigarettes currently on the market differ significantly in their risk of starting a fire, even after controlling for smoker characteristics. The eleven members realize that the particular characteristics shown to be significant may be surrogates for some other cigarette properties and smoker characteristics, unknown at this time. Despite only eight cities participating, the eleven members feel that it is unlikely that brand preferences peculiar to these localities may have influenced the results, or that a larger sample size would have yielded major differences in the principal conclusions.

By contrast, the four cigarette industry representatives note that this study did not find a statistically-significant association between reduced tobacco density (or reduced amount of tobacco), reduced cigarette circumference, or the presence of citrate in cigarette paper and the incidence of fires. These factors are three of the four cigarette design parameters that were reported in the TSG laboratory experiments to affect ignition propensity. The four assert that the presence of a filter was not reported in the 1984-87 research conducted by NIST to be a significant variable affecting ignition propensity and was not studied further by NIST under the current legislation. It is also noteworthy that demographic variations among smokers were found to be associated with fire incidence to a far greater extent than cigarette design characteristics. The field study findings raise serious questions concerning the real-world predictive value of the Mock-up Ignition Test and the Extinction Test. The cigarette design and packaging characteristics for which statistical significance was reported in the field study are based on analyses of main and first-order interaction terms. Limitations on sample size have been reported by CPSC to preclude examination of higher-order interactions for the variables that were reported to have statistical significance. The CPSC field study should be interpreted in light of this limitation.

5. Develop information on societal costs of cigarette-ignited fires. The TAG has received a rough draft and heard a presentation of estimates of the costs of smoking fire injuries by the National Public Services Research Institute, a contractor to CPSC. Based on 1990 estimates of (civilian and fire fighter) fatalities and injuries resulting from cigarette-initiated fires in structures, the annual cost to society is estimated to be \$3.6 billion, with direct property damage estimated to cost an additional \$0.4 billion. These estimates are based on a combination of new research, a comprehensive review of existing literature, and the latest cost estimation techniques. The TAG has received a next draft, but did not have sufficient time to evaluate it prior to transmitting this report.

Eleven members of the TAG find the presented work to be quite thorough. Significant benefits would accrue should cigarettes of reduced IP acquire an increased share of the market.

The four TAG cigarette industry members believe that the CPSC and its contractor used questionable assumptions and inappropriate data to arrive at a hugely inflated cost estimate. Moreover, other studies show substantial declines in careless smoking-related fires (58%) and fire deaths (45%) from 1980 through 1991.

6. Develop information on changes in the toxicity of smoke and resultant health effects from cigarette prototypes: This task reflects the concern that a small increase, due to new cigarette types, in the serious health risk that, in the view of eleven members of the TAG, already causes over 400,000 smoking-related deaths annually could overbalance the benefits that would be achieved from the reduction of fires. Since the Act limits spending to \$50,000, the TAG agreed with CPSC staff that any significant amount of actual testing of prototypes was precluded and that the preparation of a recommended testing protocol would be of high value. CPSC staff, in consultation with the Department of Health and Human Services (DHHS) and with nominations from the TAG, composed a panel of five eminent scientists in the field of cigarette smoke toxicity, supported by CPSC and DHHS representatives, to assist in developing such a plan.

Based on scientific information developed by the expert panel, the CPSC/DHHS recommended and the TAG concurred that a four-tier, performance-based test protocol be utilized for assessing possible changes in toxicity of new, low IP cigarettes. A performance-based test was judged scientifically appropriate due to the significant number of possible design variations of low IP cigarette prototypes. The protocol comprises: (1) analysis of specific chemical constituents in cigarette smoke incorporating the FTC protocol, (2) *in vitro* testing, (3) examination of changes in human smoking behavior of low IP cigarettes that might change smoke dose and exposure, and (4) *in vivo* (animal) testing. Each of the tiers (except number 3) contains specific tests that use currently-accepted and currently-used scientific technology that may be employed to demonstrate the health and/or safety for products in the U.S. marketplace and for Federal regulation of consumable products. However, not all health effects of serious concern are addressed at this time because of the impracticability or non-existence of adequate tests, high costs, or long periods needed for testing. Definition of acceptable levels of performance was deemed to be beyond the scope of the Act. Estimated costs for conducting all but the third tier (for which no estimates are available) are about \$330,000 per prototype.

Conducting a selected subset of tests represents a practical first step in implementing the plan. With input from the experts and the TAG, CPSC/DHHS recommended the measurement of tar, nicotine, carbon monoxide, pH, benzo(a)pyrene, and tobacco-specific nitrosamines from tier I, and a salmonella mutagenicity assay from Tier II. The estimated direct cost for this first step is \$6,900. CPSC directed testing of five cigarette types to demonstrate the practicability of this first step testing. The data indicate that cigarette types can be distinguished by these toxicological parameters and that the cost estimates in the plan are reasonable.

Eleven members of the TAG recognize the Toxicity Testing Plan as a substantial contribution to evaluating the changes in toxicity associated with low ignition-potential cigarettes and finds that it is a reasonable approach, especially considering the constraints imposed on the expert panel (funding, time, complexity).

The four cigarette industry representatives agree that changes in smoke chemistry may be expected to result from large modifications in cigarette design and that careful study of potential health effects that may be associated with such changes is appropriate. They note, however, that the plan has limitations as a guidance document and that issues of experimental design and the interpretation of results will require more detailed assessment than was permitted under the constraints imposed by the Act. Definition of acceptable performance for modified cigarettes also is critical. The proposed toxicity plan raises serious questions, but provides few answers at this stage of development.

II. ASSESSMENT OF THE PRACTICABILITY OF DEVELOPING A PERFORMANCE STANDARD TO REDUCE CIGARETTE IGNITION PROPENSITY

The TAG has spent considerable time discussing how to provide you with technical advice on this topic. We realize that, under the Consumer Product Safety Act (P.L. 92-573), tobacco and tobacco products are specifically not included as consumer products. However, under the Fire Safe Cigarette Act of 1990 (P.L. 101-352), the Congress requires such an assessment. The TAG presumes that there are some technical elements likely to be common to any regulatory process and that these are similar to those used by the CPSC. CPSC staff have provided us with such a list, and these elements are addressed below.

A. TEST METHOD TO CHARACTERIZE PRODUCT PERFORMANCE

Eleven members of the TAG recommend the use of the Mock-up Ignition Test Method for use in a product performance standard for the reasons given under Task 1, above. While routine measurement of the relative ignition propensity of cigarettes is feasible using either of the two methods, this method is preferred over the Cigarette Extinction Method because it demonstrated better distinction among both the commercial and experimental cigarettes. The NIST report contains all the necessary materials for initiating the adoption of either method as a voluntary consensus standard by either ASTM or the National Fire Protection Association (NFPA).

These members also find that use of the test method is likely to potentiate reduced fire losses. The current best-selling cigarettes produce consistent ignitions of all substrates in the two test methods. New cigarette designs intended to produce fewer fires and fire deaths will need to demonstrate a significant reduction in test ignitions, compared to the current best-sellers. There are no data indicating the converse, namely that cigarettes that produce fewer ignitions in the test methods will produce greater fire losses.

As noted in the above discussion of the test methods (see Task 1), the four cigarette industry TAG members believe that these are not predictive of real-world cigarette ignition propensity. They have found in their studies that ignitions of commercial fabrics under likely real-world environmental conditions may be increased by adoption of a performance standard based on the proposed NIST test methods. In addition, the predicted short-term reproducibility of the proposed test methods (40%) makes them unsuitable for use in product development or in establishing a performance standard. Longer term reproducibility has not been examined and may even be more limited in view of the reported characteristics of the cotton duck fabric relied on by NIST. Thus, at this state of development, neither of the proposed test methods should be adopted as a basis for measuring the ignition propensity of cigarettes. They assert the methods are not predictive of real-world fire risk and could be counterproductive.

B. ACCEPTANCE CRITERION

The TAG believes that the setting of acceptability criteria is in the domain of the regulator. The NIST report does provide some assistance, however. The interlaboratory evaluation of the method showed that individual test labs could differ by about 40 percent, defining the limit of resolution for use in any future regulations. There are also data to "calibrate" the method at the high and low ends

of the ignition propensity scale: the commercial cigarette test data (Task 2) establish an indication of performance for the cigarettes associated with current fire losses; some experimental cigarettes never or rarely ignited a variety of substrates.

The four cigarette industry representatives believe that consideration of acceptance criteria presupposes that a reproducible and predictive test method has been developed. At this state, they contend that neither condition has been met.

C. HEALTH EFFECTS

Eleven members of the TAG support use of the CPSC toxicity testing plan in the development of a performance-based requirement for low ignition-potential cigarettes entering the market. The plan is a reasonable approach to collect data needed to evaluate major health risks. It could be adopted as guidance or incorporated into mandatory or voluntary consensus standards. The TAG also recognizes that improvements in toxicity testing and risk evaluation may occur and should be considered during possible future revisions of the plan.

These eleven members of the TAG believe that the primary responsibility for the safety of cigarette products belongs to the cigarette manufacturers. No agency currently has regulatory authority over cigarettes. They believe that new products should not increase the risk of adverse health effects to the public above the existing risks resulting from currently-marketed cigarettes, unless such increased risk is outweighed by the reduced number of deaths and injuries from the fires prevented. The toxicity of a candidate low IP cigarette should be compared to a) the specific marketed brand/type intended for replacement or comparable marketed brands/types for a non-replacement candidate, and/or b) standard reference cigarettes. Toxicity criteria remain to be set.

The four representatives of the cigarette industry, as noted under Task 6, contend that the plan is insufficient for guiding regulation. They do agree that careful study of potential health effects is appropriate.

D. ECONOMIC AND COMMERCIAL FEASIBILITY OF LOW IGNITION PROPENSITY CIGARETTES

Eleven members of the TAG have considered the extensive series of studies conducted and sponsored by the cigarette industry subsequent to the TSG's final report in October, 1987. They conclude that these studies are not persuasive in changing the TSG's findings that "it is technically feasible ... to develop cigarettes that will have a significantly reduced propensity to ignite upholstered furniture or mattresses."

Indeed, the eleven members of the TAG find that cigarettes of reduced ignition propensity are already being marketed, presumably at a profit. This is based on the results of the CPSC field study (Task 4) and the NIST commercial cigarette tests (Task 2). Thus, these members conclude that some manufacturers have found it commercially feasible to produce and sell cigarettes of reduced ignition propensity. In addition, the TAG notes that these reduced IP current commercial cigarettes also show yields of tar, nicotine and carbon monoxide that are no different in the aggregate from the best-selling cigarettes. Thus, the eleven conclude that it is possible to achieve reduced ignition propensity

in a commercially feasible cigarette without increasing smoke toxicity (assuming that toxicity is represented by these three yields).

The four TAG members representing the cigarette industry dispute this, citing shortcomings of the methods used, as noted in the above sections on the two Tasks. They also note that assessment of the economic and commercial feasibility of low IP cigarettes was not included in the Act. Further, the six commercial brand styles tested under Task 2 have a minimal market share, indicating unacceptability to the overwhelming majority of smokers. Consumer testing (by the industry) of prototype cigarettes incorporating the low-IP features identified in the TSG study has found that they are not acceptable to smokers.

E. BENEFIT/COST ANALYSIS OF LOW IGNITION PROPENSITY CIGARETTES

Eleven members of the TAG find that a net benefit to the nation can be derived from the introduction of low ignition propensity cigarettes into commerce, assuming the incremental adverse health effects do not outweigh the fire safety benefits. This is based on three observations. First, in appraising the NIST model of economic impact in its Final Report, the TSG concluded that the cost of modified cigarettes need not be large:

"The overall effects of the cigarette modifications considered may result in only small changes in the price of cigarettes, unemployment, health care costs, life expectancy, and the financial status of the affected industries and professions."

Second, as noted under "Economic and Commercial Feasibility," cigarettes of reduced ignition propensity are already being marketed in the same price range of the most popular brands.

Third, there are likely to be significant benefits from low IP cigarettes. The TSG correlation of mock-up results with chair tests and the current NIST test method report indicate that positive test results can be expected to be indicative of reduced ignitions for significant portions of the real-world furnishings population, at least for coarse changes in test performance.

The four TAG members representing the cigarette industry disagree. They assert that cost/benefit analysis was not authorized or addressed in the current legislation and cannot begin to be conducted until a reproducible and predictive standard test method has been developed and proposed performance standards or acceptance criteria have been advanced. A wide range of critical economic considerations also were identified in the 1984-87 TSG studies as critical inputs to any assessment of the costs versus benefits of reduced ignition propensity cigarettes. It was found that a cost/benefit conclusion could not be reached on the data then available, and there has been no further study of these issues. Cigarette industry data also indicate that a performance standard based on the NIST methods may increase the propensity of cigarettes to ignite commonly-used cigarette fabrics in real-world conditions and thereby produce detriments rather than benefits. The four assert that cost/benefit analysis also should include consideration of alternate approaches to improved fire safety. They contend that California upholstered furniture flammability standards have proven feasible and effective in reducing fires and fire deaths beyond any known or realistic prediction of the impact of modification in cigarette design.

III. CONCLUSION

In conclusion, the Technical Advisory Group, by a vote of 11 to 4, believes that sufficient technology and information is available to deem practical the development of a performance standard to reduce cigarette ignition propensity.

Sincerely,

A handwritten signature in black ink, appearing to read 'R. G. Gann', with a stylized, cursive script.

**Richard G. Gann, Ph.D.
Chairman, Technical Advisory Group
Fire-Safe Cigarette Act of 1990
and
Chief, Fire Science Division
Building and Fire Research Laboratory**

cc: Members, Technical Advisory Group

Public Law 101-352
101st Congress

An Act

To direct the completion of the research recommended by the Technical Study Group on Cigarette and Little Cigar Fire Safety and to provide for an assessment of the practicality of a cigarette fire safety performance standard.

Aug. 10, 1990
[H.R. 293]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Fire Safe
Cigarette Act of
1990.

SECTION 1. SHORT TITLE; FINDINGS.

15 USC 2054
note.

(a) **SHORT TITLE.**—This Act may be cited as the “Fire Safe Cigarette Act of 1990”.

(b) **FINDINGS.**—The Congress finds that—

(1) cigarette-ignited fires are the leading cause of fire deaths in the United States,

(2) in 1987, there were 1,492 deaths from cigarette-ignited fires, 3,809 serious injuries, and \$395,000,000 in property damage caused by such fires,

(3) the final report of the Technical Study Group on Cigarette and Little Cigar Fire Safety under the Cigarette Safety Act of 1984 determined that (A) it is technically feasible and may be commercially feasible to develop a cigarette that will have a significantly reduced propensity to ignite furniture and mattresses, and (B) the overall impact on other aspects of the United States society and economy may be minimal,

(4) the final report of the Technical Study Group on Cigarette and Little Cigar Fire Safety under the Cigarette Safety Act of 1984 further determined that the value of a cigarette with less of a likelihood to ignite furniture and mattresses which would prevent property damage and personal injury and loss of life is economically incalculable,

(5) it is appropriate for the Congress to require by law the completion of the research described in the final report of the Technical Study Group on Cigarette and Little Cigar Fire Safety and an assessment of the practicability of developing a performance standard to reduce cigarette ignition propensity, and

(6) it is appropriate for the Consumer Product Safety Commission to utilize its expertise to complete the recommendations for further work and report to Congress in a timely fashion.

SEC. 2. COMPLETION OF FIRE SAFETY RESEARCH.

15 USC 2054
note.

(a) **CENTER FOR FIRE RESEARCH.**—At the request of the Consumer Product Safety Commission, the National Institute for Standards and Technology's Center for Fire Research shall—

(1) develop a standard test method to determine cigarette ignition propensity,

(2) compile performance data for cigarettes using the standard test method developed under paragraph (1), and

(3) conduct laboratory studies on and computer modeling of ignition physics to develop valid, user-friendly predictive capability.

The Commission shall make such request not later than the expiration of 30 days after the date of the enactment of this Act.

(b) **COMMISSION.**—The Consumer Product Safety Commission shall—

(1) design and implement a study to collect baseline and followup data about the characteristics of cigarettes, products ignited, and smokers involved in fires, and

(2) develop information on societal costs of cigarette-ignited fires.

(c) **HEALTH AND HUMAN SERVICES.**—The Consumer Product Safety Commission, in consultation with the Secretary of Health and Human Services, shall develop information on changes in the toxicity of smoke and resultant health effects from cigarette prototypes. The Commission shall not obligate more than \$50,000 to develop such information.

15 USC 2054
note.

SEC. 3. ADVISORY GROUP.

(a) **ESTABLISHMENT.**—There is established the Technical Advisory Group to advise and work with the Consumer Product Safety Commission and National Institute for Standards and Technology's Center for Fire Research on the implementation of this Act. The Technical Advisory Group may hold hearings to develop information to carry out its functions. The Technical Advisory Group shall terminate 1 month after the submission of the final report of the Chairman of the Consumer Product Safety Commission under section 4.

Termination
date.

(b) **MEMBERS.**—The Technical Advisory Group shall consist of the same individuals appointed to the Technical Study Group on Cigarette and Little Cigar Fire Safety under section 3(a) of the Cigarette Safety Act of 1984. If such an individual is unavailable to serve on the Technical Advisory Group, the entity which such individual represented on such Technical Study Group shall submit to the Chairman of the Consumer Product Safety Commission the name of another individual to be appointed by the Chairman to represent such group on the Technical Advisory Group.

15 USC 2054
note.

SEC. 4. REPORTS.

The Chairman of the Consumer Product Safety Commission, in consultation with the Technical Advisory Group, shall submit to Congress three reports on the activities undertaken under section 2 as follows: The first such report shall be made not later than 18 months after the date of the enactment of this Act, the second such report shall be made not later than 25 months after such date, and the final such report shall be made not later than 36 months after such date.

15 USC 2054
note.

SEC. 5. CONFIDENTIALITY.

(a) **IN GENERAL.**—Any information provided to the National Institute for Standards and Technology's Center for Fire Research, to the Consumer Product Safety Commission, or to the Technical Advisory Group under section 2 which is designated as trade secret or confidential information shall be treated as trade secret or confidential information subject to section 552(b)(4) of title 5, United States Code, and section 1905 of title 18, United States Code, and shall not be revealed, except as provided under subsection (b). No member or employee of the Center for Fire Research, the Consumer Product Safety Commission, or the Technical Advisory Group and

no person assigned to or consulting with the Center for Fire Research, the Consumer Product Safety Commission, or the Technical Advisory Group, shall disclose any such information to any person who is not a member or employee of, assigned to, or consulting with, the Center for Fire Research, Consumer Product Safety Commission, or the Technical Advisory Group unless the person submitting such information specifically and in writing authorizes such disclosure.

(b) **CONSTRUCTION.**—Subsection (a) does not authorize the withholding of any information from any duly authorized subcommittee or committee of the Congress, except that if a subcommittee or committee of the Congress requests the Consumer Product Safety Commission, the National Institute for Standards and Technology's Center for Fire Research, or the Technical Advisory Group to provide such information, the Commission, the Center for Fire Research, or Technical Advisory Group shall notify the person who provided the information of such a request in writing.

Approved August 10, 1990.

LEGISLATIVE HISTORY: H.R. 293:

CONGRESSIONAL RECORD, Vol. 136 (1990):

July 30, considered and passed House and Senate.